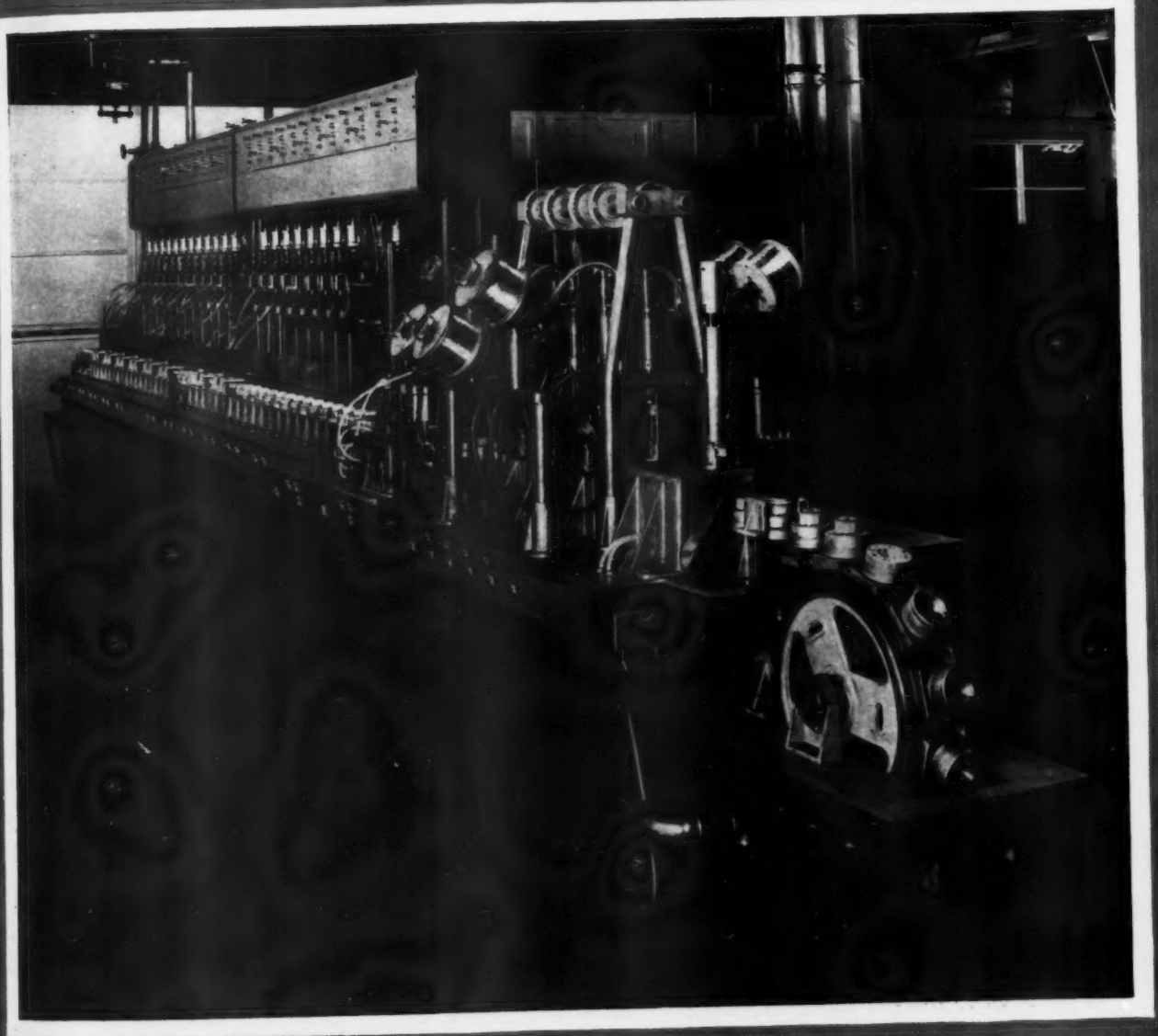
THE UNIVERSITY OF MICHIGAN
JAN 18 1960
ENGINEERING LIBRARY

THE UNIVERSITY OF MICHIGAN
JAN 18 1960
ENGINEERING LIBRARY

JOURNAL
OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 5 NO. 60 DECEMBER 1959



VOLUME 5 NUMBER SIXTY DECEMBER 1959

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* COVENT GARDEN 1871 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

Contents

687 The reading of technologists

689 Materials handling and automation
by L. LANDON GOODMAN, B.SC.(ENG.), A.M.I.MECH.E., ASSOCIATE MEMBER

694 Photoemission on film

695 Some recent developments in electrical insulation
by J. ASHMORE, MEMBER

699 Dounreay reactor critical

700 Statistics and engineering
by M. D. MCCARTHY, M.A., PH.D.

704 International Federation of Automatic Control

705 Public mobile radiotelephone service
by W. J. BRAY, M.SC.(ENG.), MEMBER

707 Institution Summer Meeting in Scotland, 1960

708 The electrical engineer's view of the home

709 Training Regulations

710 The dimensions of sound

711 The adventure of building

712 A review of the *Proceedings*, Parts A and B
(*details are given in the adjoining column*)

725 Obituary

726 Correspondence

727 Papers and monographs published individually this month
(*details are given in the adjoining column*)

728 Electronic telephone exchanges

729 Technical publications

730 Some recent books

732 Elections and transfers

733 Library accessions

735 Forthcoming events at Savoy Place

735 British Nuclear Energy Conference

735 District Meetings

736 Announcements to members

738 Contents of the current *Proceedings*

739 Bulletin of the Sections

740 London report

741 News from the Centres

744 News from abroad

BACK COVER **Index of advertisers**

712 A review of the *Proceedings*, Parts A and B

Travelling-wave resonance	J. R. G. Twisleton
Travelling-wave parametric-amplifier theory	Prof. A. L. Cullen, A. Jurkus and P. N. Robson
Ferromagnetic travelling-wave amplifiers	P. J. B. Clarricoats
Classification of waveguide modes	A. E. Karbowiak
Permanent-magnet materials	J. E. Gould
British and German engineering degrees	D. B. Welbourn, D. B. Spalding and G. L. Ashdown
Problems of engineering education	Profs. H.-G. Kayser, K. Luerenbaum, Cl. Müller, R. Sauer, H. Stefaniak and R. Wille
Electronics in jet-engine control	H. E. Coles
Speed control of squirrel-cage induction motor	G. K. Creighton and W. M. Somerville
Insulation failure	J. A. Denham

727 Papers and monographs published individually this month

PAPERS

Input impedance of rectifier modulators	Prof. D. G. Tucker
Rectifier modulators with frequency-selective terminations	D. P. Howson and Prof. D. G. Tucker
Gaseous-discharge phenomena in h.v. d.c. cable dielectrics	E. C. Rogers and D. J. Skipper
Transistors and the operation of gas-discharge lamps from d.c. supplies	I. F. Davies and D. Dunthorne
Designing housing-estate distribution systems with a computer	R. L. Grimsdale and P. H. Sinclare
Logical design of electrical networks	U. G. W. Knight
Water-turbine-driven induction generators	C. L. C. Allan
Impulse strength of impregnated-paper dielectrics	B. F. Salvage and J. A. M. Gibbons

MONOGRAPH

Positive, real and complex zeros	O. P. D. Cutteridge

Automation

THE cover picture shows part of an automatic plant for the mechanized production of radio-proximity fuse amplifiers. A radio-proximity fuse may occupy the nose-section of an artillery or anti-aircraft shell, and its function is to explode the shell when it approaches within lethal distance of the target. In the small nose-section must be packed all the components required for a miniature radio transmitter and receiver together with power supplies.

Apart from being extremely compact the fuse has to withstand the severe shock condition of being fired from a gun. The linear acceleration may exceed 20000*g*. The final design which was based on printed wiring eliminates human errors and enables amplifiers to be consistently produced to a high standard of reliability. This mechanized-assembly plant is the outcome of a design study into the logistics of such production by the Armament Research and Development Establishment, Fort Halstead, Kent.

An article dealing with some general aspects of materials handling and automation begins on p. 689

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.
© 1959: The Institution of Electrical Engineers
Advertising Office TERMINAL HOUSE, GROSVENOR GARDENS, LONDON S.W.1 *Telephone* SLOANE 7266 *Telegrams* INDULICITY, SOWEST, LONDON

The Institution is not as a body responsible for the opinions expressed in the *Journal* unless it is stated that an article or a letter officially represents the Council's views

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 5 NUMBER 60 DECEMBER 1959

THE READING OF TECHNOLOGISTS

NEARLY every technologist believes that there is too much publication of scientific information. Certainly there seems to be far too much for the average specialist or professional practitioner to absorb if he wishes to make a serious and conscientious effort to read everything of possible or potential value to him.

This situation is of course the result of the great increase in scientific investigation which has needed to be reported over the past 20 years, and it may be aggravated by the duplication which is inseparable from the publication practices of the Western World.

Until the scanning and searching of the technical literature can be carried out for us mechanically or electronically the problem will remain acute and is likely to become more so, and even when the initial searching has been done there remains the necessity for the technologist to absorb the new knowledge by reading.

Many conferences and discussions have examined the question, and generally it would seem that the scientist is more inclined to the use of the abstract-journal method of finding the articles which he must read in his particular field of specialization. Though there is a certain amount of duplication of abstracting throughout the world most of this is necessary to present the material in various tongues, and in any case most scientists seem to adopt one abstract journal as their favourite and depend on that. Some even maintain their own private abstracting index, and this particularly applies to those working in the borderline disciplines between two main fields of science.

But the technologist is not a great personal user of the abstracting journals. He normally expects the information bureau of the organization in which he works to be responsible for the searching of such journals and for letting him know about articles and papers of interest. His approach to the general mass of technical literature is more empirical. He also tends to have favourites, of which he remains a faithful reader for many years so long as his special interests remain the same.

A report by the Social Survey Division of the Central Office of Information on 'The use of technical literature by industrial technologists'* gives some absorbing results of a study of technical information in the electrical industry. The study was requested by the Department of Scientific and Industrial Research as part of a programme of inquiry into the dissemination to industry of the results of scientific and technological research. A 'popular' account of the report was published by Her Majesty's Stationery Office in October 1959 under the title 'What they read and why'.

As a sample, 1082 individuals employed in the electrical and electronics industry were asked a number of questions by the interviewers of the Social Survey. Their replies were analysed statistically and in great detail, and some of the conclusions, especially those concerned with the correlation of replies, are as the authors admit somewhat tenuous and unreliable.

But the main conclusions based on broad findings appear to be unchallengeable. One of these is that the tendency to refer to the literature in solving a problem is not simply an incidental characteristic of the good technologist nor is it merely a result of the fact that the good technologist is more likely to be given the type of problem which requires reference to the literature; on the contrary it appears to be one of the characteristics which make a technologist good.

The actual level of interest in technical literature shown by technologists is a matter for concern (and here it should be borne in mind that the survey was carried out between February and April 1956). It was found that the mean number of different journals seen regularly by the informants was 4·7 while the mean number read or scanned during the preceding year was 7·8. Pressure of time does not seem to be an important reason why the literature is used so little. The authors of the survey say 'The cost of subscriptions inhibits reading only because motivation for reading is already so weak.'

Another prime finding is that the technical literature is used much more for primary stimulation than for reference. Apparently people read to get ideas and to find out what is going on but seldom read to solve a particular

* Social Survey Report No. 245, London, Central Office of Information, 1959

problem. The relatively small use made of the technical literature for reference purposes revealed in the survey probably explains the lack of interest shown by technologists in libraries, information offices and other aids to reference. It may also explain why such a high proportion (well over 50%) of technical reading appears to be done at home.

Among journals seen but not paid for by the reader, in about one-half of the cases he reads about one article per issue; in about one-sixth he does not read on the average as much as one article per issue but he nevertheless derives appreciable value from what he does see; and in about one-third he derives little value from the journal and apparently sees it only because he does not have to pay for it.

Twenty-nine per cent of the individuals could not recall any article in any journal or pamphlet which had been of direct use or special interest to them.

Thus the main finding of the study is that the literature is used very little. The authors of the survey remark 'This might reflect a fault in the literature, a fault in the technologist, or a fault in the facilities for making the literature available to the technologist, or there might be no fault at all—it might be a good thing. Our evidence suggests that if there is a fault much of it lies in the technologist. Relative to this the facilities are not seriously faulty.'

Dealing with the belief of the technologist who seldom consults the literature that he would not readily find in it the solution to the type of problem with which he most often has to deal, the survey is unable to provide assistance; and the authors suggest that there is a need for a detailed study of the literature as it is at present, undertaken from the point of view of a technologist who has been set a particular problem. Such a study would undoubtedly be useful both to technologists and to editors, and we hope that it will be found possible to carry it out.

Meanwhile there is the notable conclusion of this survey that the literature is read very little for reference and mainly for news. As the authors of the survey point out, it seems likely that knowledge of this fact should affect the way in which the technical literature is organized.

There seems very little doubt when one reviews the mass of technical and scientific literature pouring from the presses week by week and month by month that most of the enlightenment that a technologist could possibly require is certainly there, if he knows where to find it. But bearing in mind the pace of modern living and the limitations of our processes of human communication it is unlikely that the technologist thumbing through his technical magazines as they come onto his desk or out of his briefcase will, unless by chance, find just that piece of information of which he stands in need at that point of time.

Given our present methods of exchanging knowledge and the understandable reluctance of the technologist to act as a self-contained information bureau there are two simple suggestions which might command general agreement and which would improve the chance of the technologist finding the advice he needs during his regular browsing. The first is that the browsing should be more frequent, more thorough and more widespread. Some concerns are known to insist that their technologists spend 20% of each day reading technical literature. The second is that authors and editors even in the most highly scientific fields should cultivate what might almost be called a news-reporting style.

Tradition and prejudice in this connection die hard but if it were possible to treat every scientific article and paper as a news story, bringing the highlights of the news well to the fore and obliterating unnecessary detail, we might go a long way towards solving this accessibility problem. Many will object to this idea, but the statistics presented in this survey are inexorable and reveal a state of affairs which demands a revolution in our thinking about the dissemination of technical information.

National Lending Library for Science and Technology

A CONSULTATIVE committee has been appointed to advise the Department of Scientific and Industrial Research on the services of the National Lending Library for Science and Technology (see January 1959 *Journal*, p. 45).

Literature is now being collected for the library by the D.S.I.R. Lending Library Unit at 20 Chester Terrace, Regent's Park, London N.W.1.

The new library will be located near Boston Spa, Yorkshire, and its transfer will take place in the first half of 1961. Its collection of scientific literature which will become the largest in the United Kingdom will be available through loan and photocopying services.

Dip. Tech. students doubled in a year

THE number of students in technical colleges taking courses leading to the Diploma in Technology is now nearly twice the aggregate a year ago—3320 compared with 1786. The National Council for Technological Awards has approved 29 new courses, bringing the sum up to 84. Over 1400 of the students are in their first year. The colleges of advanced technology (including the ninth, Bristol, which is to be designated in September 1960) account for three-quarters of all Dip.Tech. students.

The total of advanced students in these colleges taking full-time and sandwich courses of all kinds increased from about 4500 in 1955–56 to over 7100 in 1958–59. The plans so far approved should enable this number to be raised to about 12 000.

An electrical engineering review

621.86:621-52 Materials handling and automation

This article covers some aspects of materials handling, the movement and storage of all materials used in an industrial organization, and shows the important part that electrical engineering plays in this field.

Various novel and significant developments are described including the automatic and radio control of cranes and conveyors which are setting the scene for automatic warehousing. Electronic inspection and sorting devices are discussed.

Practical results already achieved emphasize that improved materials handling is a first step towards automation, and the author foresees the elimination of most of the associated paper work once handling is entirely automated. Mr. Landon Goodman is with the Electrical Development Association.

L. LANDON GOODMAN, B.SC.(ENG.), A.M.I.MECH.E., ASSOCIATE MEMBER

In the opinion of some competent observers production and industrial engineering have not always received the attention in money, manpower and effort that they merit. The term 'production engineering' has become linked with manufacturing, particularly in the metal-using trades, yet many of its principles can be profitably applied in all branches of manufacturing and in many other industrial activities. Thus the writer prefers the term 'industrial engineering' if for no other reason than that it is often acceptable to people in a wide cross-section of industry.

Industrial engineering may be defined rather widely as the application of scientific and engineering principles to all branches and departments in industry in order to achieve the most economical and constructive use of man, material and time.* It consists of the following parts *inter alia*: plant siting, plant lay-out, materials processing, materials handling, product design, instrumentation and control, industrial lighting, heating and ventilating, materials utilization, production control and fuel technology.

The borderline between these subjects is often quite indistinct, and therefore when a study is made all these parts should be considered, for a change in any one can and often does much affect the working in others.

Materials handling

Materials handling is a technology in its own right and covers the handling, movement and storage of all materials used in an industrial establishment. The object of a study is to eliminate wherever possible the handling and movement of material and to analyse the handling which cannot be eliminated to see whether it can economically be mechanized or should be manually carried out and whether the material can be processed while it is moving. The elements of materials handling are: material form, the shape or form of materials for efficient handling; mechanical handling, the application of mechanical-handling equipment; and human handling.†

Among the economies which can be achieved by improved materials handling are: greater output from a given floor space, elimination of bottle-necks, reduction in damage to products, increased safety, better labour and capital productivity, upgrading of personnel, increased speed of handling materials, and, resulting from these and other benefits, reduced costs, for every time material is handled something is added to its cost and nothing to its value.

Process integration (the combining of two or more processes in one situation or machine with no manual inter-process handling, or the mechanical linking together of two or more processes for automatic operation) is one of the preliminary steps in the development of automation. A stage is achieved quite close to automation when the processing and handling are completely integrated, for then instrumentation and control can be readily applied.

Materials handling is still neglected by some organizations. A materials-handling system forms an important part of an automated plant and automation which will play a large role in electrical manufacture, particularly with batch production.

Management

As materials handling impinges on the activities of most departments of any organization it is obvious that unless it (and the other parts of industrial engineering) is the responsibility of senior management there will be a tendency for the subject to be treated as relatively unimportant or to be ignored altogether, particularly in those organizations where traditional departments are strong. For example in electrical manufacturing the chief engineer is often mainly concerned with product design, and if there is not an equally senior chief production engineer production engineering will always take second place.

Compromises will have to be accepted (i.e. someone will have to give up part of his requirements) whereas what is needed is integration (in which all requirements are deliberately met) in the sense that the word is used by Mary Parker

* Several other terms have been used and some are in use today, e.g. productivity engineering, operational research; these may or may not have a different nuance. Sir Robert Watson-Watt, one of the pioneers of operational research, said that its object is to obtain the maximum effect from available resources; it has also been defined as 'quantified common sense'

† Some people might question why a new term 'materials handling' is sometimes being used in place of the older term 'mechanical handling'. Now mechanical handling implies rightly that material be handled mechanically, but handling is an unproductive operation and the first thought should be how to eliminate it wherever possible. Materials handling then is unique as it is possibly the only technology which seeks to do away with itself

Follett.* Only in this way will a company reap the full benefits which can result from improved materials handling.

As an aside it is sometimes a source of wonderment that in many factories there is so little electrical knowledge either in or used by the production departments. Even an electrical engineer on the staff is often brought into the discussions only after all production plans have been finalized and then purely to settle details of supply and distribution. This fact is all the more surprising considering the important role that electrical engineering can and does play for example in processing, handling and instrumentation and control. It seems that the importance of *electrical production engineering* should be much more publicized and given more attention, particularly now that the era of electronics and automation has arrived.

Research and development

Research and development in the field of materials handling pay off as many companies have found. There has been however too great a tendency in recent years to go and see what the other fellow is doing instead of first studying the problem. When dealing with a subject the theoretical basis of which has not yet evolved, visits can be misleading for there is a good chance that costly mistakes will be repeated. It may be that faults are unrecognized, particularly if the installation itself has been 'designed' by copying or 'improving on' an early one.

Some factories which are today held up as brilliant examples of materials handling might not so well survive an analytical examination—it might be discovered that they were over-mechanized, that money had been spent on equipment with comparatively little having been spent at the development and planning stages beforehand.

The best materials-handling scheme can usually only be achieved as a result of proper planning based on continuous research and development. The planning tools necessary include 3-dimensional models, string diagrams and work-flow charts. Money spent on these activities ensures that vital know-how is continually being built up in a company and a minimum amount of capital is expended to achieve maximum results.

Mechanical-handling equipment

The industrial truck has come to the fore in the post-war years and the battery-electric type is now recognized as the most efficient, reliable, economical and clean unit for internal works transport.

The fork-lift truck and unit load have revolutionized warehousing and storage. A much greater volume of an existing storage space can now be used, throughput is speeded, damage and pilferage are much reduced, and labour productivity is increased several-fold. Many companies with increased output would have had to build new warehouses or to extend old ones if they had not adopted this method.

An important step forward has come about with the electronically controlled truck. A wire is placed on or in the floor or ground along the desired truck route. A sensing device and control unit are fitted to the truck which then automatically follows the wire. No driver is needed and the route can be changed whenever necessary. This system can sometimes replace conveyors in warehousing and in feeding assembly shops.

Conveyors

Several new types or variations of older designs of conveyor have appeared on the market over the last few years, and new applications are continually being discovered, as witness the passenger belt conveyor system which has been operating for some time in the United States and is now being installed at one of the London Underground stations. Important advances have been made in electrical methods of controlling the drives (see Fig. 1) and the materials on the conveyor, and the use of central, often diagrammatic, control panels has expanded. Punched tape and cards and magnetic tape are used, and often the same control unit operates the related processes.

1 *Conveyor in a clock factory*

The speed of this 1560ft-long conveyor driven by four ½h.p. squirrel-cage induction motors is controlled by the factory master clock so that a circuit is completed in exactly 8h 40min running time. It stops at the beginning of each break in working hours and starts again automatically when the break ends. Thus a clock placed on the moving conveyor at a given loading point at any instant arrives back at that point exactly 24h later, and if its hands were set to a certain time when loaded its accuracy can be easily checked when it returns

The overhead-chain conveyor is much used in mass-production industries, but coming into increasing use is the preselective type which allows the material to be sent to chosen designations. One example has separate drive-chain and load tracks. Hinged 'pusher-dogs' on the chain push the load trolleys along. The versatility of the ordinary chain conveyor is increased because by means of switches loaded or unloaded trolleys can be pushed off down side lines or 'dead lines' which are in effect runways and have no driving chain. Any number of dead lines can be incorporated and several live

* Cf. Mary Parker Follet: 'Dynamic administration' (Sir Isaac Pitman and Sons, London, 1941)

lines interconnected. The switches can be selected and operated by the trolleys or remotely by say a punched-tape control unit.

Another new flexible design of overhead conveyor provides selective conveying, automatic storage and machine-to-machine loading control. Wherever trolleys must stop for an operator to carry out a particular process, a trolley stop is fitted to the side of the conveyor track. When the load is removed from the carrier the trolley moves forward to a load stop where it waits until the operator reloads it. It then becomes free to pass under the stop and continues automatically to the next unload stop.

Solenoid-operated load and unload stops are fitted where several machines perform the same process; they may be controlled by pushbuttons or by cam switches tripped by the load trolleys. Material to be processed is kept in correct sequence and its movements are accurately controlled, reducing work in progress to a minimum. What is more the shop floor is kept free.

Individual conveyors may be very long and conveyor systems are usually made up of many sections. Long conveyors require several drive units the speeds of which must be closely related. In like manner it is highly desirable that the variable speeds of individual conveyors should be easily and quickly synchronized, e.g. in assembly operations. Electronic speed control of individual drives under a master controller permits great flexibility. Electronic control of eddy-current couplings and of d.c. motors have both been used.

The optimum speeds of individual conveyors can be found by experiment, when the whole system can be 'locked' together and the speed of the whole varied in synchronism. If an individual conveyor is extended or a new method of working introduced on it, it is a simple matter to adjust its speed again.

Electrical vibrators are quite widely used. There are two types each of which has its own applications. The reciprocating electromagnet can be controlled through a rectifier unit and delivers sharp vibrations. The rotating unit consists of a motor with out-of-balance weights fitted to the rotor shaft.

An important application of vibrators is to conveyor drives. Vibratory feeders are used for feeding machines with small parts such as bottle caps, screws and nuts. One design consists of a cylinder around the inside of which runs a spiral. Small parts are vibrated up the spiral, oriented to the right position and fed into the feed mechanism. Another application is to ensure a flow of a powder or lumpy material out of a hopper or bin. Vibratory chutes are also used for controlling the feed onto a conveyor.

Magnetism is used in several ways. In one application powerful electromagnets are placed over a conveyor to remove ferrous matter in the material being conveyed. An ingenious use is to convey ferrous material up a sharp incline. In this case the belt runs over a series of electromagnets on the incline (Fig. 2).

Transfer machines

The conveyor is no longer being thought of as a machine to transport material; it has become a basic production machine. It initiates action in related machines, feeds materials into processing machines, starts and stops processing, and transports material to the next stage of processing. This development is illustrated by the linear and circular transfer machines used for repetitive machining operations in car and electric-motor manufacturing. The arrangement has little or no production flexibility such as has been recently achieved with some different conveyor methods.

Two-branch parallel systems of process conveyors are tape-controlled in the car-body paint shop of a well known Continental motor-car factory. Each set of parallel process conveyors can cater for two qualities of finish, and the bodies can be routed through any combination of loops. Owing to the different speeds of the conveyors the time taken for a particular body to pass through the system is governed by the route taken which in turn depends on the required finish.

2 *Magnetic conveyor for carrying ferrous articles up a steep incline*

This space-saving equipment is a normal band conveyor fitted with permanent magnets under the belt on inclined sections. Although the magnets do not in practice affect the parts handled demagnetizers are sometimes fitted as a special safeguard

Because it was a basic requirement that the bodies were to leave the plant in a predetermined order a computer was installed so that the starting order of the unpainted bodies could be computed. The programme is punched in a simple binary code, a group of holes containing all routing information, masking details, paint colour and finally the serial number of a particular car body.

The sprayers are informed about the colour for a body by numbers which are displayed in each spray booth; the numbers for the corresponding body are signalled from the punched-tape control. The complete conveyor system is fully automatic (there are electronically controlled drives giving speed variation) and is made up of about 50 individual conveyors.

Automatic warehousing

The same basic principles of conveyor control are now coming into use in what is popularly termed 'automatic warehousing'. Goods are mechanically routed from the receiving area to storage-area racks whence they flow to the dispatch area when called for. The whole installation is under a master controller with a memory unit which routes the material to storage areas and carries out a continuous inventory operation so that paper work is eliminated. An order for goods is placed in the control unit which then selects them from the racks and keeps them together until they reach the packing department.

Automatic warehousing is one of several composite operations which make up mass-production assembly. Parts and components have to be delivered to and stacked on conveyors, chutes and racks and then fed to various points along the line, in some instances with split-second timing. This system is used for example in the garment trade, in bottling plants, in the electric-motor industry for the production of stators, and in motor-car plants.

At a new bulk-raw-sugar handling plant at Liverpool, claimed to be the fastest bulk-sugar handling installation in the world, the 1¾ miles of belting in the conveyor system are driven by variable-speed commutator motors. Each motor is fitted with a pilot-motor-driven brush gear and is capable of continuous operation over a speed range of 3 : 1. On the main control panel each conveyor motor has its own start/stop pushbutton incorporated in a mimic diagram. The motors of a particular group can be started up only in sequence and are fully interlocked so that if any drive motor stops, the feeding-in drive motors immediately stop.

The linking of groups of conveyors to effect a desired path from the cranes to the silo is accomplished locally on the installation, and the associated control circuit is connected by means of multi-pole plugs. The installation incorporates many important features including the interlocking of the 'increase speed' control and a slip-control system as a precaution against spillage or unnecessary wear of the belting.

Electric pulley blocks incorporating high-torque squirrel-cage motors are widely used nowadays. They range in capacity from 100lb to 10 tons or more and are often built into a trolley which runs on the lower flange of an H-beam. The trolley too may be electrically driven, the power for the whole unit being supplied by a suspended cable, reeling drum or busbars.

There is virtually no limit to the extent or complexity of a runway system which can consist of a short length of girder or an installation incorporating switches, turntables, and drop-sections (sometimes electrically operated), weigh-sections, and short sections which can be fitted in the top of a lift-cage to latch up with runways on various floors of a building.

Cranes

The gantry crane is still one of the more important types of mechanical-handling equipment where loads have to be moved about in a fixed area, though for some applications as in warehousing the fork-lift truck has proved a successful competitor in the last decade.

For some of these applications a new type of crane has been developed to handle unit loads such as pallets. Beneath and fixed to the gantry crab is a mast on which is mounted a fork-lift unit which can rotate and move up or down. This crane is virtually an inverted fork truck. While it has not the flexibility of the truck it does not require the same gangway space.

Electric drives for at least one of the three motions are much more common nowadays; the smaller cranes which formerly had hand blocks for lifting are now generally fitted with electric pulley blocks. This has an added advantage with underhung cranes which latch up to runways because the electric blocks can circulate around the runway system. Standard industrial cranes still employ simple line-current drum controllers and standard slip-ring or series motors; there is no close control of the hook, and the load has to be positioned by inching. Where stable creeping speeds are necessary the thrustor-operated brake is being successfully used in conjunction with the wound-rotor induction motor on the drives not only of cranes but also of winding gear and skip hoists.

Special-purpose cranes have been made with control gear incorporating numerous modern electrical techniques including inductor radio and closed-circuit television for remote control and automatic control for process cranes with preset programming. Fig. 3 shows an overhead crane operated by two-way radio equipment. A frequency-selector system is also available for remote manual control by means of a single extra wire to the crane.

Accurate control of hoisting and lowering on a.c. supplies is achieved by reverse-current braking and d.c. injection systems. Drives with eddy-current couplings are now being fitted to all motions of cranes giving a speed range of 30 : 1 with all loads. Magnetic-amplifier closed-loop controls are used on the hoist motion. Inching is eliminated and load handling is speeded up.

Great improvements have been made in contactor gear for steel-mill cranes giving more accurate control and hence speedier working. A further development is the use of Ward Leonard equipment on these cranes to reduce the amount of or eliminate altogether contactor gear with its associated maintenance problems. Remote-control systems operated from ground level are being developed so that crane drivers do not have to be housed in bad atmospheric conditions up in a driver's cab on the crane.

Considerable progress is also being made in doing away with open bare conductors supplying cranes and in safeguarding bare cross-conductors on cranes. Another safety measure recently introduced is a crane-approach system employing high-frequency sonic equipment. The dangers of collisions between cranes and overrunning end-stops are eliminated, and complete protection can be given to maintenance men working on a disabled crane or on the crane track.

Inspection and sorting devices

Electrical, and in particular electronic, sensing devices play a large part in materials handling for inspection, indication and sorting. Which to use in a particular application often causes much heart-burning. Hopper-level control may use photocells, isotopes, capacitance probes, conducting probes, pressure switches or a lever switch, depending on the material

3 *Overhead travelling crane being operated by a two-channel radio equipment*

in the hopper, well indicating the wealth of electrical methods available.

The photoelectric cell has many applications. Typically it is used to operate a process in synchronism with material passing on a conveyor line such as the spraying of paint or fat while the articles are immediately in front of the guns. In a mattress factory a belt conveyor line carrying interior filling runs along one side of the assembly shop and comprises a number of individual sections. Benches are positioned at intervals at right-angles to the conveyor line. Each section of conveyor is monitored by a light ray, and a control system is arranged so that if the filling is removed from any section that section and the preceding ones start up. Thus material flows along the line and when the gap is filled the sections stop. In this way the requirements of the workers are quickly met.

Limit switches have caused serious trouble in the field of mechanical handling. Interesting therefore is the development of the flameproof magnetically operated proximity switch which was designed for colliery hoists. It is useful whenever a moving part must operate a switch without necessarily making material contact with it.

Radio control

V.h.f./a.m. radio has many uses in controlling industrial-truck systems and railway-siding operations. One interesting use of a walkie-talkie set is in a quarry to permit the operation of a ropeway and grab during periods of bad visibility; without the set, working would have to shut down. The application of industrial television is only in its infancy in British industry yet many of the installations are already being used to facilitate and speed the handling of material.

The remote feeding of furnaces and the loading of large subassemblies into machines are carried out with the aid of television. At a steelworks two industrial cameras are carrying out a tedious and uncomfortable task previously undertaken by two men who are now usefully employed elsewhere. Bars 21 ft long and weighing from 15 to 30 cwt are pushed into furnaces by machinery operated from a control cabin. The cameras keep a constant watch and the operators see clearly on the monitor screen when the bar is correctly positioned in relation to water-cooled skids for pushing into the furnace.

Process integration

The efficiency of many operations can be improved by a study of the methods of feeding processes. Closed-loop control has here a large part to play. Typical of successful applications are cloth-guiders on stentering* machines, the photoelectric loop feeding of presses, vibratory feeders, and various specialized mechanisms. The form of material is often a vital matter in achieving automatic feeding, and a new term has been coined to express this requirement. 'Kinetic packaging' is the packing of articles in such a form that they can be immediately loaded into a process after transport without any unpacking.

This technique is illustrated by the placing of resistors and capacitors on a pressure-sensitive tape in a reel somewhat similar in appearance to a machine-gun belt. The reels are delivered ready for use and loaded onto a component-inserting machine on a printed-wiring assembly line. Kinetic packaging is an elementary form of process integration which is being developed in many industries.

Another simple example of process integration is the high-speed check weigher designed to check the weight of canned and packaged goods in a weight range from a few ounces to several pounds at rates up to 250 per min and with sufficient accuracy to satisfy Board of Trade requirements. The equipment counts and rejects under- or over-weight articles. Another relatively simple example is induction-hardening of a component in the working position in a machine tool immediately after it has been turned or worked, thus eliminating handling.

A more complex example is the piston line at a motor-car plant. Special machines have been designed and built with automatic cycling and handling into and out of the machines

* A stenter is a frame or machine on which fabrics are stretched between hooks or by means of rollers so that they do not shrink while drying

so that they can be linked at will as the need arises. Ultimately they will become a completely integrated line.

A further step forward is shown by a fully automatic machine, 175ft long, on which all the four gears of a motor-car gearbox layshaft are cut and checked. In this line there are 18 gear-cutting and finishing machines with four inter-operational washing machines and three automatic gauging equipments. The machines are linked together by work-transfer conveyors with which the components are automatically loaded and unloaded at the machines.

The same technique is being applied to assembly operations. An automatic line consisting of a group of five machines has been developed for assembling, filling, testing and packing carbon microphones. The machines are connected by synchronized transfer mechanisms. The assembling group comprises two automatic machines each of which has an indexing table with 12 positions driven by an air cylinder operated by a micro-switch and magnetic clutch. The first machine assembles the front of the capsule, and in it 11 different operations are performed simultaneously at 11 work stations. The capsule is transferred by a chain conveyor to the second machine which assembles the rear side on the 12-station indexing table carrying out nine different operations.

Process integration has applications in all sizes of production unit; indeed some of the most interesting applications have been in quite small plants on batch production. Sometimes of course it is necessary to modify or change the design of the product before the technique can be successfully applied. For example with electrostatic paint spraying it is often desirable to eliminate sharp corners on the articles being sprayed. If this is not done it may be necessary to touch up these corners by hand spraying afterwards thus reducing the efficiency of the combined process and handling operation.

Summary

Many new developments in materials handling are just around the corner. The computer will control not only processing operations but handling as well. The beginning of this trend is to be seen in automatic warehousing and in applications of the simple analogue computer as at the Wissington sugar factory. No doubt when the handling is entirely automated, paper and associated paper work will be almost, perhaps entirely, eliminated. In the meantime the parallel flow of paper should be studied as carefully as the flow of materials. Exactly the same approach is made, first seeing what paper processing can be done away with and then studying the remainder to find if mechanization or electronic data-processing can be economically applied.

This parallel study can assist in the streamlining of production and eases the introduction of automation. Even simple pieces of apparatus such as tape recorders can replace written documentation. In sorting, pricing and packing in a laundry their application has increased by up to 30% the number of articles with which each girl in the department can deal. At a wholesaler's warehouse a checker is no longer required for the loading of lorries, the lists being 'read out' by machine. This again allows over 30% increase in labour productivity.

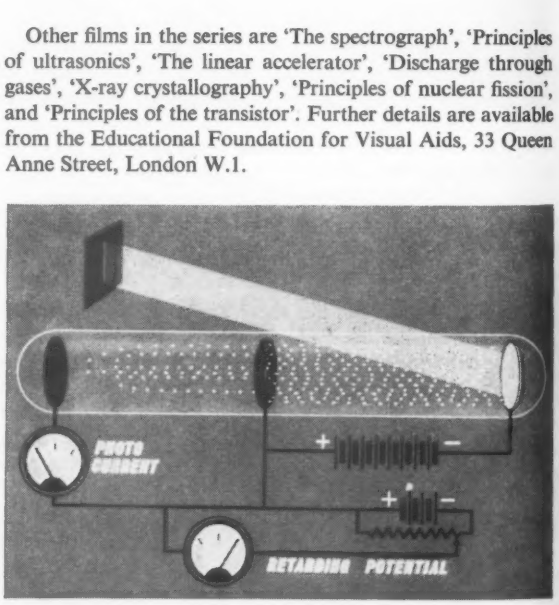
Photoemission on film

One of the more difficult concepts to get across to science sixth-formers and technical-college students at a similar level is photoemission, involving as it does a switch from the classical wave theory of light to the quantum theory. Moreover many school textbooks are as yet inadequate on this subject and experimental equipment of the type used by industry and research laboratories is beyond normal school resources.

Thus the medium of the film is an excellent one in which both to expound the basic theory and to illustrate how it is verified and used by today's scientists. 'Photo-emission', the latest addition to the Advanced Science Series of the Educational Foundation for Visual Aids, is a 16mm sound film in black and white running for 18min designed for these tasks.

It opens by presenting the construction of a modern photoelectric cell. Such a cell is then exposed to monochromatic light of variable density, and the first law of photoemission is obtained. A further demonstration establishes how the energy of electrons is affected by the intensity and frequency of the light source, and the second law is derived. Animated diagrams show that the quantum theory explains these laws, and the film closes with scenes of photoelectric cells at work including their use in magazine printing for colour registration, in image convertors and in photomultipliers.

Other films in the series are 'The spectrograph', 'Principles of ultrasonics', 'The linear accelerator', 'Discharge through gases', 'X-ray crystallography', 'Principles of nuclear fission', and 'Principles of the transistor'. Further details are available from the Educational Foundation for Visual Aids, 33 Queen Anne Street, London W.1.



This still from the film 'Photo-emission' depicts the apparatus used for determining the maximum energy of emitted electrons

SOME RECENT DEVELOPMENTS IN ELECTRICAL INSULATION

621.315.611

Advances in electrical plant and equipment have called forth developments in insulation depending on new materials primarily from the plastics industry. Good heat transfer is one of the main requirements in the application of some new insulating materials described in this article based on part of the author's Chairman's Address to the South Midland Centre in October 1958. Mr. Ashmore is with British Electrical Repairs Ltd.

J. ASHMORE, MEMBER

THE prime object of electrical insulation is to restrict the flow of electricity to the correct channels. Any fault in the insulation may have dire results such as the complete destruction of the machine or apparatus. Furthermore the electrical properties of the insulation must provide a high degree of safety.

Thermal conditions play a large part in the selection of insulation and British Standard 2757: 1956 'Classification of insulating materials for electrical machinery and apparatus on the basis of thermal stability in service' was based on the temperature limits drawn up by the International Electrotechnical Commission.

Moulded stone

In connection with solid insulation a recent development is 'moulded stone', a combination of ceramic and plastic as calcium aluminosilicate.

It is not a thermoplastic but it is moulded under pressure up to 10000lb/in.^{2} and after moulding is cured by high-pressure live steam. For electrical applications the components are subsequently baked and may be impregnated with wax to maintain the electric strength (50–80 volts/mil).

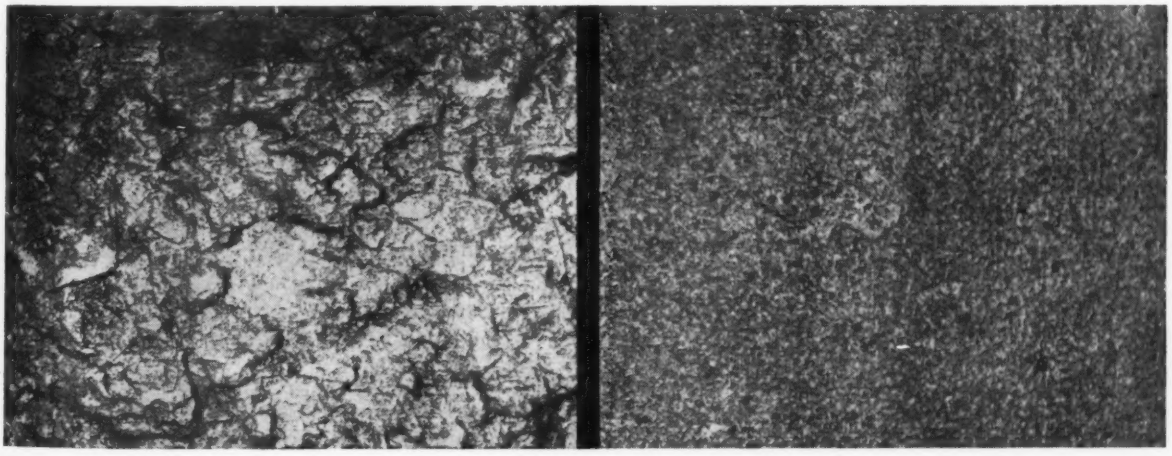
Advantages claimed for moulded stone are its exceptional arc-resistance, heat resistance up to 482°C, and low tracking characteristic. A common use is for small contactor components and terminal blocks for which it is admirable.

Integrated mica

An important development is the introduction of 'integrated mica' which is manufactured in France and the United States under various trade names. The process was developed by a Frenchman, Jacques Bardet, who started his experimental work during the Second World War and managed to keep it secret from the Germans during the occupation of France.

In the process mica is heated in a furnace so that a controlled amount of combined water is driven off and the splittings just begin to separate. The heating is critical so as to ensure that although the crystal lattice is weakened the structure is not destroyed and the essential properties of mica are retained. The hot mica is plunged into sodium carbonate solution which seeps between the

1 *Surfaces of commutator-grade insulating materials compared (about 7/8th full size)*
(left) micanite; (right) integrated mica



laminates and forces the splittings further apart. The mica is then easily broken into small pieces by mechanical means.

After a thorough washing a slurry of these fine pieces is fed onto a paper-making machine. The resultant paper is impregnated with resins, and backing and facing materials are applied to make sheets and tapes.

2 *Flow diagram for manufacture of integrated mica*

The outstanding property of this material is its uniformity. Fig. 1 illustrates the evenness of the surface. Fig. 2 gives the flow diagram of the French process. Integrated mica is used in Great Britain for applying to backing materials and also for commutator separators. The thickness is controlled and there are no mica-rich or resin-rich areas. The electric strength, although lower than the maximum for micanite, is higher than the average for that material.

Integrated-mica boards can be made by incorporating shellac, epoxy, silicone, glyptal and inorganic bonds. Commutator separators are excellent, and the seasoning of large commutators is expedited because the yield after the first baking and pressing cycle is so small. Tubes are stronger than those made in conventional materials.

Weftless glass tape

Weftless glass tape was recently introduced. It consists of non-woven parallel glass yarns impregnated with a catalysed polyester which binds the yarns together. It is used for armature and rotor binders in place of the conventional steel binder and is a self-insulator.

This method of binding eliminates the effects of eddy currents which often occur in steel binders, and it has been used successfully for about two years on traction armatures up to 4500 r.p.m. and various types of armature up to 1500 h.p.

Application is easy. It is usual to apply the tape when the armature or rotor is hot, thus eliminating voids between layers. A tensioning device is used, and for medium-size armatures and rotors the tension is 175–225 lb and for large armatures and rotors including traction armatures 400–600 lb, the end of the band being secured by soldering.

Balance weights can be applied to the glass band. A special lead-weighted epoxy is employed which is combined with a catalyst just before use and is applied after first sanding the varnish off the band. An infra-red lamp hardens the compound. Another method is to apply small pieces of copper-plated lead about $\frac{1}{16}$ in. thick which are secured by high-strength epoxy adhesives.

A further application for weftless glass tape is in the manufacture of small- and medium-size transformers having cold-rolled grain-oriented silicon-iron cores. The less hole-punching and bolting of this type of core the better, and the use of weftless glass tape to bind the limbs has eliminated much mechanical work.

Polyurethane-varnished fabrics

Polyurethane-varnished fabrics, using nylon, Terylene and glass, and polyurethane–glass are regarded as class F 155°C insulation and are now extensively employed on the end-windings of turbo-alternator stators.

Fig. 3 shows the stator-winding overhang of a 10 MVA 11 kV 3-phase testing alternator taped with polyurethane–glass finished with raw glass and varnished. Fig. 4 is of a stator coil for a 750 h.p. 6·6 kV 3-phase synchronous motor and shows the polyurethane–glass tape on the ends before the application of the finishing raw-glass tape. This motor is for use in the tropics and the varnish applied has a chemical additive to prevent the growth of fungus.

Polyurethane varnishes have excellent heat-ageing properties and give a tough, flexible film with exceptional electric-strength/stretch characteristics. The treated fabrics, especially tapes, bind nicely. The varnishing process must be rapid because a catalyst has to be added immediately before use.

The surface finish of electric-motor windings is important. A high-gloss varnish finish particularly eases the removal of dirt during regular maintenance attention and helps to seal the windings.

High-tenacity rayon tapes

High-tenacity rayon tapes now available are made from continuous-fibre yarn which gives a very smooth

finish and after varnish treatment a high gloss with fewer coats of finishing varnish. Blistering such as is experienced with cotton is eliminated and the tape has good tensile strength and excellent resistance to abrasion, meets class E conditions and in most widths is slightly cheaper than cotton.

New types of insulation in the class E range have assisted in the development of electric motors to comply with B.S. 2083: 1956 'Dimensions of 3-phase electric motors (totally enclosed fan-cooled)' and B.S. 2960: 1958 'Dimensions of 3-phase electric motors with ventilated enclosures'. These permit a maximum temperature increase of 65°C instead of 40°C for class A insulation.

Silicones

The term 'silicone' covers any organic silicon compound based on a silicon–oxygen structure with hydrocarbon radicals attached to the silicon atoms. When we use silicones we move into the most expensive field of insulation. The cost ratio of thermosetting varnish to silicone varnish is about 1 : 8.

Silicone insulating materials were first produced commercially in America in 1943. All are comparatively inert and are remarkably unaffected by heat (180°–250°C) or cold (−40°C and below). The viscosity of silicone fluids and greases is constant with change of temperature, a valuable characteristic. Other advantages of silicones include high water repellence and good resistance to corona, ozone, fungus and tracking. Their most significant feature is that in the event of electrical breakdown or heat degradation silicon is formed instead of the usual conducting carbon.

3 *Stator-winding overhang of a 10 MVA 11 kV 3-phase testing alternator taped with polyurethane–glass finished with raw glass and varnished*

Their disadvantages are low mechanical strength, poor resistance to solvent oils and chemicals, and high cost. When a machine is silicone-insulated *all* the insulating materials must be silicone-treated or trouble will occur as many have discovered to their cost.

It is a fallacy that a machine with class A insulation has better thermal properties if the insulation is impregnated with silicone varnish. The thermal properties depend on the base materials used and are not affected by silicone varnish. In machine construction frame sizes

4 *Stator coil for a 3-phase synchronous motor*

can be 'up-rated' to develop more power if the electrical design is modified to suit the new rating.

In the manufacture of flexible and solid silicone insulation it is important to ensure that the base or carrier material is capable of resisting the high temperatures that silicone varnish will withstand. Glass textiles are mostly used, in the form of cloth or tape. Silicone varnish increases the electric strength of the glass fabric about 15 times.

The surface of silicone or other varnished glass fabric has a rough appearance. This is due to what the glass-textile people call 'hairiness'—small broken fibres that project and cause irritation to operators. Glass-fabric irritation does not cause dermatitis and normally with new operators irritation ceases after three or four days.

Silicone-varnished glass fabric is available in all widths and thicknesses, straight- and bias-cut. It has the same electrical characteristics as its conventional counterparts but better power factor and insulation resistance and high mechanical strength. However in difficult taping operations it is liable to fracture. With mica, such as in the form of a glass/mica or glass/mica/glass sandwich, it is used as a slot liner and for transformer insulation.

Silicone elastomer

Glass fabric coated with silicone elastomer has an exceptionally high extensibility. It has all the virtues of silicone-varnished glass fabric and much greater flexibility and softness.

The fabric is available in the semi-cured or semi-

vulcanized condition and when taped on a coil and heated shrinks and bonds to form a homogeneous waterproof jacket. Recently it has been produced in a fully cured and self-adhesive form and the latest development is unsupported silicone elastomer. This is extruded as a tape with a marker line. It is fully cured and self-sealing and very resilient. Experimental work with it is now in progress on traction motors.

A recent problem was the conversion of the insulation of a 300 kVA 200 c/s transformer to class H. Fig. 5 illustrates the primary winding, a toroidal coil of rectangular-tube copper conductor for water cooling. The spaces between the turns are filled on the inside of the coil with half-moon wedge-shaped pieces of silicone–glass laminate with silicone-elastomer paste over-all. After curing the whole is taped first with silicone-treated glass/mica/glass, then with elastomer–glass and finally with raw glass. It is brush-varnished with silicone as each layer of tape is put on, and finally several coats of varnish are applied.

Glass-saturated sleeving is suitable only for low voltages. Extruded silicone-elastomer sleeving can be used at up to 20 kV according to wall thickness.

Cast resins

Developments in cast resins include the encapsulation of sensitive components on the introduction of low-shrinkage-on-cure resins and research into blowing-on a plastic paste to form a foam round the component before it is cast in the resin so as to provide a cushioning effect on shrinkage.

It is important to insulate properly the laminations of a magnetic circuit, particularly those of cold-rolled grain-oriented silicon-iron sheet. Cores using these steels are being worked at flux densities of up to 16 500 gauss so that any fault in the insulation causes serious eddy-current losses. These losses must be kept to a minimum if the advantage of the steel is not to be lost.

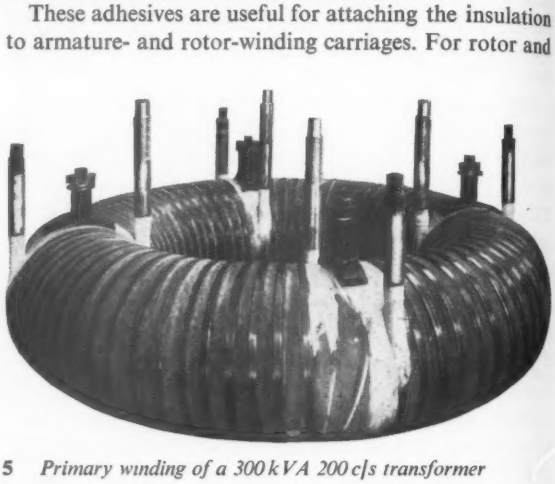
The proper insulation of laminations demands not only good varnishing of the sheets but also good mechanical work. The shearing of the sheets must be clean with very little burring.

Synthetic-resin adhesives

Synthetic-resin adhesives are extensively used in rotating-machine windings and on static plant and apparatus. They are epoxy resins of Swiss origin.

There are some interesting applications in rotating machines; for instance mouldings are made with glass-cloth backing to form inserts for the transpositions on the stator bars of large alternators. Another use is for binding over commutator risers to prevent the between-riser blocks from slipping; in addition the fronts of the risers are moulded, the result being a very sound fixing which is much better than that provided by mica with steel binders which are inclined to slip.

These adhesives are useful for attaching the insulation to armature- and rotor-winding carriages. For rotor and stator end-windings large lashing rings are made on formers and machined to shape.



5 *Primary winding of a 300 kVA 200 c/s transformer*

For static apparatus porcelain-to-porcelain or porcelain-to-metal joints can be made.

Insulation of large turbo-alternators

The insulation of water-cooled turbo-alternators is an important subject in view of the great increase in single-machine outputs up to 275 MW. The design of these machines calls for a co-ordination of the conductor circuit, insulation and heat transfer. The stator conductor is a rectangular copper tube which can be insulated in the conventional way. The cooling is by distilled water passing through the tube in direct contact with the heated copper. The heat transfer is almost perfect and it is possible to remove up to 16 times more heat than by conventional cooling.

It is clear that the success of these large machines depends very much on the insulation. Distilled water has a resistivity high enough for it to serve as an insulator. In the first machine of this type (30 MW) a conductivity of 2·5 megamhos/cm was obtained and the water loss in the insulating-tube connections to the water headers was less than 1 kW. The machine had a terminal voltage of 11·8 kV, and it withstood 24·6 kV for 1 min between phases and to earth with full water flow through the conductors.

Power cables

A recent development in the power-cable field is the use of varnished Terylene. This insulation is non-

hygroscopic. It enables l.v. cables open to the atmosphere to work at up to 130°C compared with 80°C for varnished-cambric-covered cables. Varnished-Terylene-covered cable has been employed in the thermonuclear experimental plant Zeta.

Transmission voltages are continually being increased. In Britain 132kV lines have been supplemented by 275kV lines. Sweden has 400kV and the Soviet Union 500kV lines. The Americans are studying voltages from 460 to 750kV, and no doubt the 1 MV line will come into operation eventually.

The towers for these h.v. lines are of the portal type instead of the conventional double-circuit kind and for 750kV would be 160ft high. Seven systems are operating at over 300kV in the world and many more are anticipated: we in this country contemplate 380/420kV and Sweden and the Soviet Union 525kV and there are a number of experimental lines on which research into insulation and other related problems is being carried out.

The insulation problems with these very high voltages are many and varied. The design of strings of insulators made of a ceramic such as porcelain or glass is critical. Corona loss must be minimized and the possibility of flashover reduced. The strings must be protected against damage from lightning flashover. All this calls for much research and ingenuity. The insulation of the transformers, transformer bushings and h.v. switchgear has also to be considered.

The maintenance of insulation levels on overhead lines needs careful attention, particularly in countries like Britain where atmospheric contamination is heavy. In Sweden the air is comparatively clean, and it is possible to use outdoor capacitors for power-factor correction on the 400kV lines.

Summary

Electrical plant and equipment develop heat in operation. The conductors, normally copper, melt at 1083°C. Aluminium which is also used melts at 659°C. The insulation necessary to restrict the flow of electricity to the correct channels chars and is destroyed at much lower temperatures.

The present practice is to remove the conductor heat without damage to the insulation and to ensure long life for the latter by retarding degradation. We are confronted by a heat-transfer problem of great magnitude which is continually under review by research into the properties and applications of organic and inorganic insulating materials.

Coupled with this, research and development in metallurgy are increasing the output and power and reducing the dimensions of electrical machines.

Existing insulating materials are being improved and new materials, especially synthetic types, are being produced with more stable electrical and thermal characteristics.

DOUNREAY REACTOR CRITICAL

THE fast breeder reactor at Dounreay went critical on the 14th November 1959. The reactor will go through a period of low-power operation for some months. This may be followed by a shutdown for any modifications found necessary and the reactor will then be worked up to power in stages.

Construction work on the reactor began in May 1955 and it was scheduled to commence operating in 1958. Redeployment of staff after the Windscale-pile incident and certain design changes delayed the start of operation.

The reactor has a central core in the form of a hexagonal prism approximately 21 in. high and across the flats. The core is made up of about 360 enriched-uranium rods in niobium cans and is surrounded by a further 2000 rods of natural uranium in the blanket.

A proportion of the neutrons make their way into the blanket where they produce plutonium.

Plutonium can be used in the core to produce more heat and more plutonium. The amount of fissile material produced in the core and in the blanket during operation will exceed the quantity burned up in the core. The neutrons are not deliberately slowed down as in a thermal reactor, i.e. no moderator is used.

The small size of the core and its high heat-rating make it essential to conduct the heat away rapidly. This is achieved by placing the whole of the core and blanket in a stainless-steel vessel filled with liquid sodium–potassium alloy. The alloy is circulated by electromagnetic pumps through the vessel and through 24 heat-exchangers arranged radially round the vessel.

The heat-exchangers consist of two concentric stainless-steel tubes, the inner carrying radioactive liquid metal which is circulated through the core and the outer non-radioactive liquid metal which is piped to a heat-exchanger house and used to raise steam.

The steam produced in the heat-exchanger house can drive a turbo-alternator which is installed.

Alternatively the heat can be rejected by passing the steam to sea-water condensers.

The reactor with its primary heat-exchanger circuits is installed in a concrete vault within the 135ft-diameter steel sphere which dominates the Dounreay site.

In its early stages this experimental reactor will be operated to obtain information on the physics and control characteristics of the system. There will then be a stage of intensive development and testing of different types of fuel element.

From this experience much knowledge will be gained for the design of a prototype fast power reactor.

Statistics and engineering

658.562:519.28

A discussion of two engineering problems by M. D. McCarthy, M.A., PH.D.

Two of the many tools which the industrial statistician has at his disposal are acceptance sampling and control charts. In the first part of this article the author illustrates the basic concepts involved in acceptance sampling by comparing two different sampling specifications. In the second part he deals briefly with the theory, construction and use of control charts. The article is founded on part of a lecture given by Dr. McCarthy before the Irish Branch on the 15th January 1959 on 'Probability and statistics in engineering problems'. The author is at the Central Statistics Office, Dublin.

In order to illustrate the ways in which probability and statistics can be applied in production engineering, as opposed to the methods of design and analysis which are more normal in the research and development departments, two approaches are discussed: quality control by acceptance sampling, and fault warning and routine control by control charts.

ACCEPTANCE SAMPLING

It is universally recognized that there is need for some control of the quality of goods furnished by a mass-production process, and in many cases this control is exercised by examination of the product at one or more stages of its production. The use of sampling methods in carrying out such inspections is becoming increasingly common and a description of some of the basic concepts involved may be of interest.

Here we consider only the sampling of individual articles and not that of bulk solids or liquids unless these are already in discrete units such as cans or packages. Furthermore it is assumed that the result of the test will be to classify unambiguously an article as defective or not, i.e. the discussion deals with attributes only and not variables. The quality of a consignment or batch or lot of articles is then measured by the proportion of defectives in it.

Those who are unfamiliar with modern sampling theory are apt to take one of two extreme attitudes on the question whether sampling methods should be used in the field of inspection and quality control. Some say they cannot risk making the mistakes that are inevitable if sampling is used—they cannot risk less than 100% inspection. Certainly in some cases such an attitude may be reasonable, but very often the cost of 100% inspection cannot be justified by reference to the risks avoided and in many cases it has its own errors and their associated risks of mistaken decisions.

The other extreme uninstructed attitude is that of the industrialist who may have been forced to use sample control by the fact that the tests made necessarily involve the destruction of the articles produced but who is unaware that sampling errors exist.

In the first instance one must convince the 100-per-center that the risks associated with sampling can be calculated and controlled and that it is often good business to run such calculated risks and use samples. In the second the adequacy and efficiency of the sampling plans in use must be examined and the user persuaded that it will pay him to make his sampling efficient and to calculate and take into account the associated risks. To design efficient sampling plans and to measure the risks associated with sampling it is necessary to use statistical concepts and in particular that of probability.

Sampling specifications

Let us take two sampling specifications:

Specification A. A sample of ten units shall be selected from a consignment and tested in accordance with a specified procedure. If no unit in the sample fails the test the consignment shall be deemed to comply with the specification. If more than one unit in the sample fails the test the consignment shall be deemed not to comply. If only one defective unit is found in the sample a further sample of ten articles is selected and tested and the consignment shall be deemed to comply with the specification only if no unit in that sample fails the test.

Specification B. A sample of 40 units shall be selected from a consignment and tested in accordance with a specified procedure. If three or more units in the sample fail the test the consignment shall be deemed not to comply with the specification. Otherwise the consignment shall be deemed to comply.

If one of two such specifications is to be included in a contract, which would a buyer choose and how much protection would it give him? It is possible that an undue proportion of consignments of such poor quality that they are of little use to the buyer would be accepted by one or both specifications. What is the position of the seller in regard to them? Will either or both of the schemes involve the rejection of a high proportion of lots which he would regard as satisfactory?

We begin the examination of specification A by considering what happens in successive samples from a series of consignments all of which have a known proportion of defectives, say 5% of all articles in the lot. We calculate the probability that such lots will be accepted or rejected under the specification in question. The word probability means the proportion of such consignments which will *in the long run* be accepted or rejected by the scheme. We assume that the method of obtaining the sample is a satisfactory one and that it involves a suitable process of random selection from the consignment.

Now the probability that any individual article is not defective is 0·95 (i.e. unity minus the probability that it is defective) so that if the consignment is sufficiently large the probability that none of the ten articles in the first sample is defective is $(0{\cdot}95)^{10} = 0{\cdot}599$; i.e. in the long run 59·9% of

such consignments will be accepted by the specification on the basis of the first sample. The probability that one, and only one, article will be found defective in the first sample is $10(0{\cdot}95)^9 \times (0{\cdot}05) = 0{\cdot}315$ so that in the long run in such cases judgement will be suspended and a second sample drawn in 31·5% of all consignments. The residual 8·6% of consignments will be rejected outright on the basis of the first sample.

If the second sample of ten is drawn the probability that it will contain no defective article is again 0·599 so that this proportion of the samples held in suspense will be accepted by the second sample; i.e. $31{\cdot}5 \times 0{\cdot}599 = 18{\cdot}9\%$ of all consignments will be accepted at the second test or $59{\cdot}9 + 18{\cdot}9 = 78{\cdot}8\%$ (more accurately 78·7%) of all consignments will be accepted on the combined test of both samples. An exactly similar computation can be made on the assumption of different proportions defective in the original consignments; the results are shown in Fig. 1.

A similar examination can be made for specification B for each given percentage of defectives in a consignment. If the proportion of defectives is again 5% the probability of an individual article passing the test is 0·95 and the probability of the sample of 40 passing the test (i.e. of its containing two, one or no defectives) is $(0{\cdot}95)^{40} + 40(0{\cdot}95)^{39} \times (0{\cdot}05) + 780(0{\cdot}95)^{38} \times (0{\cdot}05)^2 = 0{\cdot}677$. Thus in the long run 67·7% of the consignments with 5% defectives will be accepted by specification B. The results of the calculations for this specification with different percentages defective are also shown in Fig. 1.

The curves in Fig. 1 illustrate the power of each specification to distinguish between satisfactory and unsatisfactory consignments at whatever level of the proportion of defectives in the consignment is deemed satisfactory. These are called the operating-characteristic curves (OC curves) of the sampling schemes.

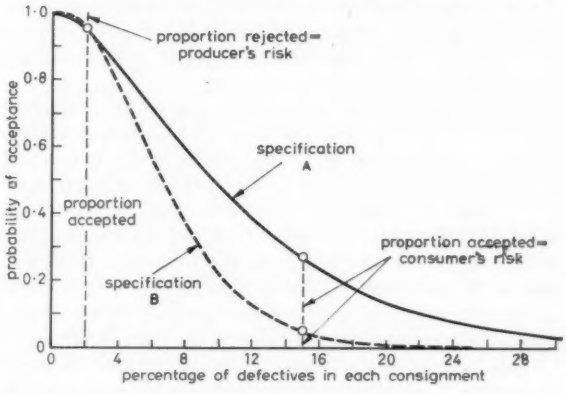
Producer and consumer risks

Let us consider separately the interests of producer and consumer of the consignments of articles which have to meet the specifications in question. Each side has a certain level of the proportion defective in a consignment at which it aims and which it is willing to accept. The producer's interest is simply to ensure that whatever sampling scheme is operated it will not reject an undue proportion of consignments satisfactory to him; he does not care how many unsatisfactory lots are accepted.

Likewise the consumer wants the scheme to ensure that an undue proportion of consignments unsatisfactory to him are not accepted; he does not care how many satisfactory batches are rejected. Of course consumer and producer in this context may be different branches of the same factory and in real life producers and consumers do not define their interests so narrowly.

In the case of such acceptance criteria based on sampling there have to be taken into account not only the two levels of the proportion defective in the consignments related to the producer's and consumer's requirements but also the risks which each party is willing to take that the 'true' classification of the consignment may be different from that determined by the sampling plan. For a consignment for which the actual proportion defective is exactly at the producer's critical value there will be a certain probability that the lot will be rejected by the sampling plan. This is called the producer's risk. Similarly the probability of accepting a consignment in which the proportion defective is exactly at the consumer's specified critical value is called the consumer's risk.

Suppose the notional producer aims at having not more than 2% defectives in the consignments he produces and that he is willing that for lots just at this limit 5% may in the long run be rejected by the sampling plan. Will either or both of the above specifications suit him? From Fig. 1 we see that at this



1 *OC curves, producer's and consumer's risks*

level of defectives in the consignment 95·3% of the lots will be accepted and 4·7% rejected by specification A and 95·4% accepted and 4·6% rejected by specification B. Thus the producer's risks, at 4·7 and 4·6% respectively, are less than the specified level and differ little so that apart from the extra cost of taking and testing the larger samples required by specification B there is little to choose between them from this producer's point of view.

The position would be quite different if the producer regarded consignments with 5% defectives as satisfactory to him. In such a case specification A would accept only 78·7% of the lots while specification B would accept 67·7% of them in the long run. In this case neither sampling scheme would satisfy the producer's requirements and another one which would give a greater accuracy would have to be devised. Specification A with a producer's risk of 21·3% would of course appear to the producer to be preferable to specification B with one of 32·3%.

Suppose on the other hand that the consumer's requirements are much less stringent and that at a pinch he is willing to accept consignments with up to 15% defectives but that he wants to be sure that lots with a high percentage of defectives will be rejected in 95% of all cases in the long run. Reference to Fig. 1 shows that consignments with 15% defectives will be accepted under specification A in 26·5% of the cases. Under specification B the proportion accepted at this level will be only 4·9%. The consumer's risk in the first

case is thus 26·5 and in the second 4·9% so that obviously specification A is much too risky for him and he will clearly opt for specification B.

The statistician's task

Most industrialists will regard it as well within their competence to fix the limits of the proportion of defectives in a consignment which they will consider satisfactory. However if sampling procedures such as those outlined are to be used to control such proportions defective another dimension has to be introduced into the technical or business decisions. The difficulty of settling the risks to be run by either producer or consumer in adopting a sample scheme involves a decision of a different order from that involved in considering the actual proportions defective.

If either producer or consumer wants a high degree of assurance that the sampling scheme will acurately determine the 'true' classification of a consignment at the limit which he specifies he might choose a risk of as low as 1% or even 0·1%. This will almost certainly involve the taking and testing of large samples which of course costs money. The producer and consumer will have to balance the cost of such inspection against the risk of making wrong decisions on the basis of the sample. To make such a choice will usually be difficult but it is a business or technical decision and not a statistical one.

Once the decisions are made it is the task of the statistician to produce a sampling scheme which will conform to them and at the same time involve the minimum of cost. To do this economically he will probably need some further information such as the usual distribution of the percentage defective in successive consignments produced by the process in question.

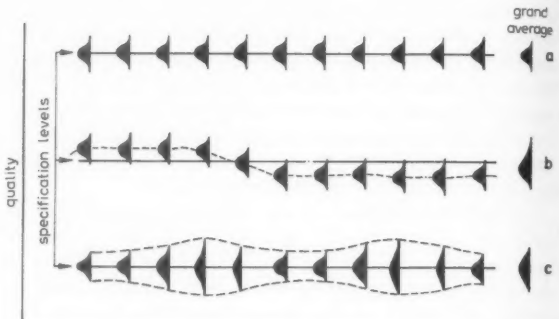
When he has adequate information he has at his disposal many different sampling methods involving simple sampling, double sampling, sequential sampling, etc. and it is his task to select from these the method which will suit the particular situation and will conform to the requirements most satisfactorily and at least cost.

CONTROL CHARTS

One of the most fruitful applications of the theory of the normal or Gaussian distribution in the engineering field has been in the use of control-chart methods in quality control. In an ideal system of mass production all the factors that determine the quality of the finished product must be known and maintained at appropriate levels so that every article produced is of the desired standard.

This naturally can only be an ideal: in practice no matter how carefully the materials and processes are controlled the finished product will vary in quality. Raw materials, particularly those of biological origin, cannot be made uniform. Operators differ in skill, both between individuals and in a given individual at different times, and it is impracticable to exercise such supervision as will eliminate entirely the human factor. Machines and tools wear and it would be completely uneconomic to use them only for the short period between the time they are run-in and the first appearance of slight wear. All these sources of variation are present in most processes and cannot be eliminated.

If this is so and if these and these alone are the causes of variability the resultant variation in the finished product is described as allowable. Sometimes there are also the variations which occur when things go wrong, when by investigation and perhaps experiment the causes of the deviations can be identified and controlled. The object of statistical method in this field is to separate such preventable



2 *Types of lack of control*
a Control correct
b Mean out of control
c Variability out of control

variations due to assignable causes from the allowable variations and to provide a ready warning system which will indicate when preventable variations are occurring.

Theory

Let us first suppose that the measurement of quality in question at some stage of the production process results in a particular measure x for each individual item; x may be for example some linear dimension of a mass-produced machine part. The state of the process at any time is described by the frequency distribution of x at the time in question. Let us assume that, as often happens, the distribution can be taken as conforming to the normal one. If we could measure a large number of items at each time we could determine the distribution at successive intervals of time. How can lack of control manifest itself in these distributions?

If the process is in control the distribution will be exactly the same at each interval. It will be centred on the specification level at each time of testing, and the allowable variations are represented by the small black frequency distributions shown in Fig. 2a.* The frequency distribution obtained by pooling the results from a number of successive tests will be exactly the same as for each individual test.

Fig. 2b shows what happens when the mean of the process goes out of control but the spread or variability (measured by the standard deviation) remains constant. The horizontal line represents the specification level, the dotted line that

* Fig. 2 is based on a diagram in TIPPETT, L. H. C.: 'Technological applications of statistics' (John Wiley and Sons, 1950)

followed by the means of successive samples. All black frequency distributions on the diagram are of the same shape but are displaced from the correct centring. The frequency distribution of the pooled results from the several tests will show more spread than the individual constituent distributions and also may be skewed in shape. Such a result means that assignable causes are in operation.

Fig. 2c shows a second type of lack of control where the mean remains at the specification level but the distributions vary in spread. The average quality remains constant but because of the changes in the scatter an undue proportion of faulty items are being produced at certain times. The pooled distribution will also be centred on the specification level with a spread intermediate between those of the constituent distributions.

In addition the two types of lack of control can occur together where both mean and spread may wander; the individual distributions are not then simply related to the pooled distributions. The control charts, usually two in number, are designed so that both types of lack of control can be detected.

Construction of control charts

Small samples are slippery customers and it must be recognized that the amount of confidence which we can attach to any conclusions from a sample is closely related to its size. An individual small sample will indicate when some radical change has taken place in a process; a more gradual change will be discovered as successive small samples create a cumulative impression. For this to operate the sampling must be done systematically.

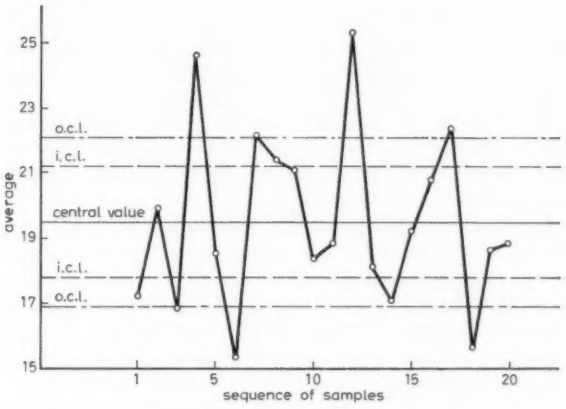
To check the types of lack of control already mentioned we must have two charts, one of which examines deviations in the mean and the second of which signals lack of control in the standard deviation, usually by plotting the range. On both charts certain limits are marked which indicate when the process is out of control. We wish to arrange that the probability of the out-of-control signal being registered when in fact no assignable source of variation has arisen shall be reduced to some acceptably low level, and the theoretical formulae of the normal distribution enable this to be done.

First a series of samples of four items are taken from the process while under careful supervision which eliminates all known assignable sources of variation. These items are measured or tested individually and the results recorded. The arithmetic average of all the results is found and taken as the 'central value' on the chart of averages (see Fig. 3 where this is 19·5). The individual averages of the 20 successive samples of four have been entered in Fig. 3.

Some control limits must also be entered on the chart to indicate when the sample averages are wandering unduly from the control value. These are computed from an estimate s of the standard deviation σ which measures the variability in the individual measurements. This can be calculated by taking the range w for each sample of four and finding the average ($\bar{w}$). This works out at 3·50, and since we know that with samples of four the mean range is 2·059 times the population deviation the estimate for the standard deviation of the distribution of the individual measurements $s = \bar{w}/2{\cdot}059 = 1{\cdot}70$.

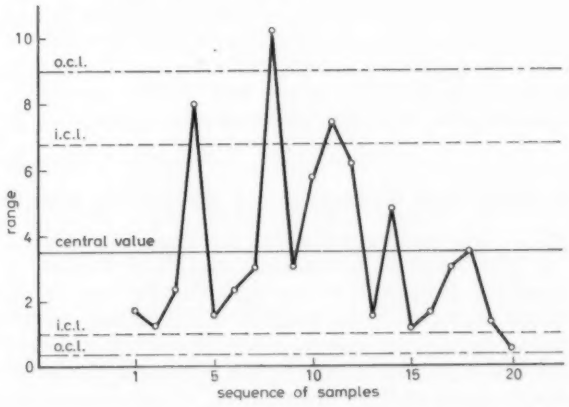
Inner and outer limits

Now the standard deviation of the distribution of averages of n is $s/\sqrt{n}$ which in this case is $s/\sqrt{4} = 0{\cdot}85$. It is usual to draw two sets of limit lines on the chart, the inner of which might be expected to include the sample averages 19 times out of 20 and the outer to include them 998 times out of 1000. The inner control limits (i.c.l.) are horizontal lines drawn at the central value $\pm 1{\cdot}96$ standard deviation of the sample mean ($=19{\cdot}5 \pm 1{\cdot}96 \times 0{\cdot}85 = 21{\cdot}2$ and $17{\cdot}8$). The



3 (above) *Control chart: average*

4 (below) *Control chart: range*



outer control limits (o.c.l.) are drawn at the central value $\pm 3{\cdot}09$ standard deviation of the sample mean ($=19{\cdot}5 \pm 3{\cdot}09 \times 0{\cdot}85 = 22{\cdot}1$ and $16{\cdot}9$).

Instead of multiples of 1·96 and 3·09 times the standard deviation of the sample mean the round figures 2 and 3 are sometimes used and the limits are then called the 'two-or-three-sigma limits'. Then the proportion of cases outside will be 0·046 and 0·0027 instead of 0·05 and 0·002 which of course does not usually matter.

Fig. 4 shows the ranges of the individual samples. The

distribution of range is not normal and consequently the control limits will not as in Fig. 3 be symmetrically placed round the central value which here is 3·5. The inner control limits are, for samples of four, $0{\cdot}29\bar{w}$ and $1{\cdot}93\bar{w}$, there being 0·025 of the frequency less than the lower value and 0·025 greater than the upper. Similarly the outer control limits are $0{\cdot}10\bar{w}$ and $2{\cdot}58\bar{w}$ corresponding to 0·001 of the frequency below and 0·001 above these limits. In the example the i.c.l.'s are 1·0 and 6·8 and o.c.l.'s 0·4 and 9·0. These are shown in Fig. 4 with the individual ranges for the 20 samples of four units.

An examination of Figs. 3 and 4 suggests that there is less than adequate control of the basic process. Four of the observations for the average are above the upper and three below the lower o.c.l. while three are between the inner and outer control limits. In the case of the range one observation is above the upper o.c.l. and three observations are between the control limits. These instances should be investigated to see whether assignable causes of variation can be found in relation to them. If such causes can be discovered they should be eliminated and the work redone with a further extended series of samples, the charts being finally redrawn when control has been achieved. They can then be used to indicate when the process is beginning to go out of control.

Uses of control charts

A control chart can be used first as an instrument to investigate when a process is out of control. This may occur either when a process is new and all the conditions which affect quality may not be known or have been brought under control, or when things go wrong. In either case the charts show when things are wrong and when to look for the assignable causes. They do not of course tell what the assignable causes are and still less what the remedy is, but very often the pattern of the variation may give a clue to the cause. The trouble may start with the introduction of a new batch of raw material. A deviation from the specification level may indicate a wrong setting in a machine, or an increase in variability may point to undue tool wear or some mechanical fault in a machine.

A second application of control charts is to routine control of quality when the conditions cannot be determined or controlled *a priori*. In cotton spinning for example all conditions may be kept as uniform as practicable and yet the yarn may change from time to time in count and fineness. The yarn can be tested periodically and if the count changes appropriate adjustments can be made to the machines. The value of the control chart is that it systematizes such control.

Thirdly, even when perfect control is attained the control chart gives evidence of this, and it can therefore be used to keep the organization up to scratch and provide a continuous measure of quality to convince consumers be they inside or outside the factory of the quality of the product of a process.

Finally the chart can be used to reconcile design and manufacture. When the control limits appropriate to the normal running of a process have been arrived at it may be found that the amount of tolerance thus indicated is either greater than or less than the specification limits being worked to. In the former event it will be necessary either to relax the design tolerance or to use an improved machine; in the latter it will be apparent that the tool in use is too good for the job and that productive resources are being wastefully used.

Summary

Very often industrial statistics tends to be thought of as relating only to the design and analysis of technological experiments but this outlook needs to be enlarged greatly when the needs of the operating side of industry, as opposed to research and development, are considered. There are many statistical tools which are useful to the industrial engineer and the uses of two of them have been briefly outlined in this article. If such methods are to be appreciated and effectively applied a wider dissemination of the basic ideas of probability and statistics among engineers and managers at all levels is essential.

International Federation of Automatic Control

THE International Federation of Automatic Control (IFAC) held its first general assembly in Chicago in September 1959. With the President, H. Chestnut (United States), in the chair the delegates of 13 national member bodies, having been authorized to represent five additional member organizations, resolved on a new constitution of IFAC, elected some new members to the executive council and made decisions in connection with the preparation of the first IFAC congress to be held in Moscow from the 27th June to 6th July 1960 (see p. 737).

The new constitution provides for an increased participation of the national member bodies in the elections of the members of the executive council and the chairmen of the technical committees. The position as well as the tasks of the advisory committee and the technical committees are more accurately defined.

The executive council now consists of these members: President A. M. Letov (Soviet Union); Past-President H. Chestnut (United States); 1st Vice-President Ed. Gerecke (Switzerland); 2nd Vice-President O. Benedikt (Hungary); Treasurer M. Cuénod (Switzerland); Ordinary Members J. G. Balchen (Norway), J. F. Coales (United Kingdom), G. Evangelisti (Italy), K. Kaneshige (Japan), P. J. Nowacki (Poland) and Z. Trnka (Czechoslovakia).

D. P. Eckman (United States) will remain chairman of the advisory committee and J. Loeb (France) was appointed vice-chairman.

About 400 abstracts from 19 countries were submitted for presentation at the Moscow congress in 1960. Since that figure was deemed too high, only about 300 authors were invited to submit their full paper. The papers and discussions will be presented for the most part in English or Russian but it is hoped to arrange translations from and into French and German.

Preprints of all papers will be made available some months before the congress.

PUBLIC MOBILE RADIOTELEPHONE SERVICE

This is an outline description of the new radiotelephone system provided by the Post Office which enables calls to be made to and from cars in the South Lancashire area and subscribers on the public telephone network. If the demand for the service is satisfactory it is to be extended throughout the country. Mr. Bray is staff engineer of the Inland Radio Branch of the Post Office Engineering Department which was responsible for the planning and provision of the scheme.

W. J. BRAY, M.SC.(ENG.), MEMBER

ON the 28th October 1959 the Postmaster General, Mr. J. R. Bevins, opened the first public mobile radiotelephone service in the United Kingdom by making a long-distance call from a car near Lymm in Cheshire to Lord Rootes in London. He explained that the scheme which covers South Lancashire, the Wirral and North Cheshire is intended to test the demand for such a system.

Coverage of the service area

The service uses frequencies of about 160 Mc/s, intermediate between those used for television broadcasting in bands I and III. Using radio transmitters with an output of a few watts and the relatively simple aerial which can be employed on a car the range obtainable with a satisfactory signal/noise ratio is generally some 15 or 20 miles but may be more or less depending on the nature of the terrain. Thus a number of base stations must be used if a large area is to be covered. In the case of the South Lancashire scheme there are two radio base stations, each for transmission and reception, one at Winter Hill near Horwich (4 miles NW. of Bolton) and the other at Lancaster House, Liverpool.

1 *The service area*

In addition a base station for reception only has been provided at Telephone House, Manchester, in order to improve the coverage in that city. The locations of these stations and the service area are given in Fig. 1. Tests show that the coverage is mainly very favourable within the service area. However there may be a few blind spots of limited extent, owing to local screening by hills, buildings, etc., where transmission and reception are not wholly satisfactory. On the other hand good operation may be obtained on hills well outside the nominal service area.

The arrangement of radio channels used in the scheme is shown in the Table:

station	channel function	transmitting frequencies (Mc/s)	
		base	mobile
Horwich	calling	164·05	159·55
	1st traffic	164·1	159·6
	2nd traffic	164·25	159·75
	engineering development	164·35	159·85
Liverpool	calling	164·05	159·55
	1st traffic	164·15	159·65
	2nd traffic	164·2	159·7
	engineering development	164·3	159·8

Separate frequencies 4·5 Mc/s apart are used for each channel in the base-to-mobile and mobile-to-base directions of transmission; this enables several transmitters and receivers to be operated at the same site without mutual interference and permits duplex working if required.

Separate calling and traffic channels

Separate calling and traffic channels are provided, the calling channels being on the same frequencies at the Horwich and Liverpool base stations. Calling is by voice, a loudspeaker in the car-radio equipment enabling the

mobile subscriber to listen for calls from the operator intended for him. As soon as contact is established between the operator and the mobile subscriber both switch to a traffic channel nominated by the operator in

2 *Control unit, telephone handset and monitoring loudspeaker mounted in car*

order to free the calling channel. Two traffic channels are available at each of the radio stations and more can be added when traffic growth justifies it. An additional pair of channels has been provided to facilitate engineering studies for the further development of the system.

The basic pattern of radio frequencies from which the channels are selected is one with 50 kc/s spacing between adjacent channels. Studies are in progress to determine the practicability of 25 kc/s spacing with a view to greater economy in the use of the spectrum.

Frequency modulation is used with pre-emphasis at the transmitters and de-emphasis at the receivers of 6dB per octave. By this means an improvement of several decibels in the signal/noise ratio is achieved with little additional expense. The maximum frequency deviation of the modulated carrier is ± 15 kc/s. The electrical characteristics of the base and mobile radio-station equipment are closely similar to those agreed internationally for the maritime public-correspondence v.h.f. radiotelephone service.

Base stations

At the base stations separate aerials consisting of half-wavelength dipoles with coaxial feeders are furnished for each transmitter and receiver. The arrangement of the aerials has been carefully planned to avoid interference between the various channels. The effective radiated power (e.r.p.) of each of the base-station transmitters is 35 watts. The power of the mobile radio stations is limited to 25 watts (e.r.p.) by licence, most mobile stations at present using about 15 watts (e.r.p.).

The satisfactory operation of a mobile radiotelephone service necessitates the use of complex voice-operated equipment at the base stations in order to ensure that the transmitters are fully modulated not only by the strong speech signals from nearby loud-talking subscribers on the inland telephone network but also by the relatively weak signals from distant or quiet-talking subscribers. Other voice-operated equipment suppresses noise or interference from the base-station receivers that might otherwise be apparent in the gaps in speech; it is also necessary to prevent received signals from being re-radiated by the transmitter owing to imperfections in the balance of the hybrid transformers at the point of interconnection of the transmitter input and the receiver output with the 2-wire inland telephone circuit.

At the mobile stations the telephone handset, control unit and monitoring loudspeaker are usually mounted on the dashboard of the car (Fig. 2) and the transmitter and receiver in the boot (Fig. 3).

Several features have been incorporated in the system to ensure that a high standard of performance is maintained at all times. Thus the equipment for the calling channel is completely duplicated to guard against failure. In addition 'mobile' equipment has been installed at two permanent locations simulating conditions in a car at the fringe of the service area. This enables the operating staff to make test calls at any time to confirm that the base stations are functioning satisfactorily.

Operation of the service

A telephone subscriber wishing to call a mobile radio station asks for the South Lancashire Radiophone Service and is connected to Peterloo Telephone Exchange,

3 *V.H.F. radio transmitter and receiver mounted in car boot*

Manchester. The mobile-service operator at Peterloo Exchange energizes the calling-channel transmitter at the base radio station by means of a control signal transmitted by land line and calls the required mobile

radio station by voice. The mobile-radio-station subscriber hears the call on the monitoring loudspeaker connected to his receiver. He lifts his telephone handset and establishes voice contact with the mobile-service operator who then nominates a traffic channel for completion of the connection with the telephone subscriber.

In the case of calls originated by the mobile subscriber the operation of the 'press to talk' switch causes the mobile-service operator at Peterloo Telephone Exchange to receive a lamp signal indicating that a call is desired.

The Ministry of Transport has stressed the importance of road safety in using the radiotelephone service and has pointed out the need for users' attention not to be distracted from the road. Thus if a call is lengthy or engrossing it is best to stop at the first convenient place.

The car-radio equipment is not provided by the Post Office but is available from a number of United Kingdom manufacturers who are also prepared to make arrangements for its regular maintenance. The apparatus is required to conform to specification TSC53(d) published by H.M. Stationery Office, and to be generally approved by the Post Office.

A radio licence costing £7 10s. a quarter is required. Three-minute calls within the nominal service area cost 2s. 6d. Calls outside the service area (they can be made to and received from any part of the country) are charged at normal trunk rates plus a radio charge of 2s. for a three-minute call. There are alternative tariffs which are advantageous for large users of the service.

Further development

If the demand is adequate the extension of the scheme will require planning of the service areas to avoid overlaps or gaps and careful selection of the frequencies to prevent mutual interference.

The system uses simple voice-calling techniques; increased loading of the channels by more mobile units will call for the introduction of selective calling methods. These may involve the use of pulsed tones or combinations of tones which permit specific mobile units to be called without the necessity for continuous aural monitoring. In addition the possibility of dialling from the mobile unit is under review.

Solid-state microwave amplifiers

THE Institute of Physics announces that its Electronics Group in conjunction with the Radio Spectroscopy Group is arranging a conference on solid-state microwave amplifiers to take place at the University of Nottingham from the 6th to 8th April 1960.

The subjects to be covered by the conference include masers, parametric amplifiers, and related resonance studies.

Accommodation will be available in one of the university halls of residence. Further particulars and application forms are available from the Secretary of The Institute of Physics, 47 Belgrave Square, London S.W.1.

Institution Summer Meeting in Scotland, 1960

As announced on p. 629 of the November 1958 *Journal* the Summer Meeting of The Institution will be held in Scotland in 1960 at the invitation of the Chairman and Committee of the Scottish Centre. Members are asked to note that the period of the meeting has been changed from that originally announced and it will now take place from Monday evening, 27th June to Friday evening, 1st July 1960. It is hoped to circulate further details with the January 1960 *Journal*.

The following message has been received from the Scottish Centre:

*Cèud mile fàilte**

As a result of the President and Council having accepted the invitation of the Scottish Centre to hold the Summer Meeting in Scotland in 1960 the fiery cross has gone out! A warm welcome awaits you all. In 1955 the meeting was held in the North of Scotland. In 1960 the venue, based on Glasgow, is from the West of Scotland to the hills of central Perthshire.

A varied and interesting programme has been planned beginning with a civic reception by the Lord Provost and Magistrates of the City of Glasgow in the famous and beautiful City Chambers which many will remember.

Although the programme is varied it is designed to avoid a rush and will be taken at a leisurely pace. There will be sailing on Loch Lomond, a trip down the Clyde and visits to an atomic power station, to factories where beautiful carpets are made, to the capital city of Scotland, and many others, indeed something of interest to everyone.

We in Scotland look forward with great pleasure to your visit.

* A hundred thousand welcomes

BRITISH REACTOR EQUIPMENT FOR NORWAY

CONTROL apparatus of British design and construction, a reactor transfer-function analyser, has been successfully installed in the boiling-heavy-water reactor at Halden, Norway.

The equipment will enable the reactivity of the reactor to be sinusoidally modulated over a range of frequencies from 10 to 0·002c/s and will measure the phase and amplitude of the resulting neutron-flux response to within 1° and 1% respectively. It will be used to obtain data on the physics and dynamic behaviour of the reactor.

The analyser was designed at the Atomic Energy Research Establishment, Harwell, for the Halden reactor project. This reactor, moderated and cooled by heavy water, is situated near a wood-pulp and paper plant 120km south of Oslo. It is the first boiling-heavy-water reactor in the world and the first boiling-water reactor in Europe.

The electrical engineer's view of the home

THE Institution's Panel on Adequate Wiring for Electrical Installations in Buildings recently prepared their replies to a questionary issued by the Housing Standards Sub-Committee of the Central Housing Advisory Committee of the Ministry of Housing and Local Government. These replies were approved by the Council at a recent meeting.

Members of The Institution may be interested to read the evidence put forward by the Panel and a summary of this is given below.

Floor space

In both houses and flats more floor space and better planning of kitchens are needed to ensure among other things that suitable floor and wall space is available for electrical appliances such as refrigerators, washing machines and spin-dryers and for developments in existing appliances, e.g. horizontal electrical cookers. The likelihood of new appliances (e.g. home freezers, dish-washing machines and garbage disposers) coming within the reach of occupiers should be borne in mind. A utility room is of value particularly for laundry and clothes-drying purposes.

Heating

The Panel pointed out that the use of electric floor-warming systems (usually on an off-peak tariff) was rapidly increasing. Floor-warming systems installed at the time of construction of the home, using electric heating cables in solid concrete floors, offer low capital cost and relative simplicity of installation compared with conventional heating systems. It is of course possible to achieve floor-warming by circulating water (electrically heated or otherwise) in embedded pipes, but then space for a heat source, pumps, etc. has to be provided; with embedded wiring external parts can be reduced to a minimum. Floor-warming by embedded electric conductors is thus well suited to low-cost building.

Practical advantages include the elimination of the need for fireplaces, chimneys and provision for fuel storage; in the case of small dwellings this may provide as much as 25 ft^2 additional floor space in a house of given external dimensions and in the case of multi-storey structures may lead to decisive capital economy. The greater flexibility of space utilization of a room heated by floor-warming should not be overlooked. Heating in lower-cost homes is also being improved by the growing use of electricity for other forms of background heating (e.g. by electric convectors).

Asked to say to what extent they foresaw a demand for whole-house heating systems even if they cost more in capital and running the Panel observed that except in the more expensive houses the general trend at the present time was to confine permanently installed background-heating systems to living-rooms, halls and kitchens although an increasing tendency for the floors of bathrooms and toilets to be heated was foreseen in the future. As a rule radiant heating appears to be preferred for bedrooms and there is no evidence of any general demand for permanently installed background-heating systems in these rooms.

The Panel stressed that the provision of adequate thermal insulation was a major factor in improving the efficiency and thus reducing the running costs of heating systems.

Kitchens

On the question of the location of the kitchen the Panel felt that the increasing use of refrigeration made the provision of cool larders of less and less importance, which allowed greater freedom in the siting of the kitchen.

Condensation in kitchens caused by flueless fuel-fired appliances is often a serious nuisance leading to quick deterioration of decoration but it can be abated quite cheaply by the provision of an electric extractor fan. Little or no condensation is caused however when electricity is the source of heat for cooking and heating since it gives off no water vapour or other product of combustion. Moreover electric laundering appliances, namely washing machines and spin-dryers which avoid the need for boiling or for drying by evaporation, eliminate the problem of condensation on wash-day.

Laundry facilities

The Panel opposed the suggestion that laundry facilities should be provided in bathrooms and referred to the requirements of the Wiring Regulations in this connection.

Number of socket-outlets

The Panel described as outmoded the distinction drawn in the questionary between lighting and power points and called attention to the advantages of the ring-circuit system of wiring.

They were disappointed that the recommendations made in Post War Building Study No. 11—Electrical installations 1944 and in the Ministry of Health Housing Manual 1949 had only rarely been adopted in low-cost building. The Post War Building Study had recommended a minimum of three socket-outlets in living-rooms, double bedrooms and kitchens (plus one connection for a cooker and one for a refrigerator) and two socket-outlets in single bedrooms. A connection for a water heater and socket-outlets for laundering had also been recommended.

The Panel stated that it was not unusual to find homes being built today with only one socket-outlet per room.

Furthermore the Panel felt that the recommendations of the Post War Building Study now fell far short of the number considered desirable if the user was to get the maximum convenience from the use of electricity. As a general indication they felt that the number of socket-outlets per room recommended in the Post War Building Study might well be doubled and even then the number would fall short of what would be considered essential in some other countries.

The Panel presented a list of socket-outlets which they recommended as a desirable standard, and without going into details of the fixed or portable appliances mentioned in the list it is sufficient to say that they suggested six socket-outlets

for the kitchen, six for the living-room, five for a double bedroom and three for a single bedroom.

The Panel also provided evidence of the 'percentage saturation' for various electrical appliances in the total number of dwellings which illustrated the greatly increased usage since 1944. This growth was a factor that had to be allowed for in determining the number of socket-outlets to be provided in a home which would remain occupied for at least 30 years. The Panel emphasized the advantages of the ring-circuit and of an adequate number of socket-outlets in avoiding the need for adaptors and long trailing flexible cords.

Socket-outlets should be located not less than 5in. and preferably as high as 9in. above floor level except in kitchens, sculleries, wash-houses, etc. where the height above floor level should be 4ft 6in.

Lighting

With regard to lighting, the Panel reaffirmed the recommendations of the Post War Building Study as follows:

'Two lighting points in the kitchen (one controlled by two-way switching where there is more than one entrance) and at least one lighting point in each of the other rooms, including the bathroom and lavatory, and in the hall and landing, provision in this case being made for two-way switching. The understair cupboard, loft and cellar, and back and front doors should all have lighting points. Provision should also be made for the separate illumination of the larder and large cupboards. The need for lights in shallow cupboards may not generally arise in small houses and flats provided that care is taken to hinge the doors of such cupboards so that on opening they shall not screen the natural and artificial illumination.'

They observed that there was an increasing tendency towards the use of decorative wall- and concealed-lighting fittings. The growing popularity of standard lamps emphasized the need for more socket-outlets.

Lighting switches should be fixed 4ft 6in. above floor level, those in rooms not more than 9in. from the architrave of the door opposite to the hinged side. If the bathroom switch is out of reach of a person in contact with a fixed bath it may be wall-mounted, but otherwise a cord-operated ceiling switch or a wall switch placed outside the bathroom should be used.

Safety

The Panel pointed out that full compliance with the Wiring Regulations would ensure electrical safety. The provision of an adequate number of socket-outlets conferred additional safety.

TRAINING REGULATIONS

THE Council of The Institution have authorized the publication of 'Training Regulations'.

Much of the content will not be new to those who have been concerned with the training of students and graduates, but the Regulations indicate the importance which the Council attach to the ordered arrangement of this phase of a young engineer's preparation for his chosen profession.

What is new is the recognition that some electrical organizations are unable to offer an organized type of training known as apprenticeship. The Regulations accept that in these cases effective training may be obtained by a junior engineer while holding a position on the staff of a chartered electrical engineer. The preferred methods of training remain graduate apprenticeship and student apprenticeship, the latter being most effective when accompanied by a sandwich form of education.

The Regulations also permit a Graduate member of The Institution to obtain an official evaluation of his training as soon as he has completed it. This, it is hoped, will be of great assistance to such men in planning their careers.

Copies of the Regulations may be obtained on application to the Secretary of The Institution.

LARGEST SINGLE-SHAFT TURBOGENERATORS

THE Central Electricity Generating Board intend to place contracts for the most powerful single-shaft generating units (each of 350MW) yet ordered in Great Britain. Two machines are for Drakelow C power station near Burton upon Trent.

The associated boilers will be of the reheat type producing 2450000lb/h of steam at 2400lb/in.^{2} and 568°C.

Drakelow C power station will eventually have a total installed capacity of about 1500MW. As the site of the station is a focal point in the Supergrid transmission system no additional overhead transmission lines will be needed.

There are already two post-war power stations on the Drakelow site. These are Drakelow A with a capacity of 240MW (commissioned in 1954) and Drakelow B with a capacity of 480MW and due for completion in 1961.

PATENTS DELEGATION TO RUSSIA

THE Comptroller-General of the British Patent Office led a small delegation to Russia last month to discuss the protection available in the Soviet Union for British inventions.

The Russian authorities agreed in May 1959 to provide facilities for a United Kingdom team with a knowledge of patents procedure to study the working in the Soviet Union of the laws for the protection of inventions. This is a subject which grows in importance as trade increases.

The Russian patent law of 1941 is available for study in Britain and a few Russian patents have been taken out by United Kingdom firms. But the law has recently been revised and there is little knowledge in Britain of how Russian procedure works in practice. The Soviet Union is not a member of the International Industrial Property Convention to which most of the Western nations as well as the majority of the countries of Eastern Europe belong.

The dimensions of sound

A review of the convention on stereophony

STEREOPHONY is now established in the cinema, stereophonic gramophone recordings are appearing on the British market and beginning to take a hold on the American, and the transmission and reception of stereophonic radio programmes are receiving serious consideration. The convention on stereophonic sound recording, reproduction and broadcasting held at Savoy Place on the 19th and 20th March 1959 therefore provided a timely opportunity to take stock of present achievements and to formulate ideas for the future.

About 400 attended, and four papers and several contributions were presented; summaries of the papers appear on p. 711. The scene for the convention was set in the first, general, session by T. Somerville who reviewed the systems in use, indicating a possible incompatibility of stereophonic with existing monophonic systems where broadcasting is concerned. Attention was thence conducted to psycho-acoustic aspects, and the basic mechanisms of hearing and listening were examined by F. H. Brittain. He was followed by J. J. Figwer of Poland who discussed the influence of the acoustical properties of rooms.

Technical sessions

The general session over, the next three were strictly technical and dealt with tape and film recording, broadcasting and gramophone records respectively. An improved magnetic recording system was described by A. D. Burt and D. R. Andrews who hoped thereby to overcome many of the user's problems mentioned by G. F. Dutton in his critical review of tape recording. Their technique uses a tape cartridge rather than a spool.

D. E. L. Shorter's survey of stereophonic broadcasting in session 3 was followed by descriptions by W. S. Percival of a compressed-bandwidth transmission system and by J. J. Geluk of the MS recording technique. In the latter method the information for left and right loudspeakers is obtained by the addition and subtraction of the outputs of two microphones, one (the 'mid') facing the sound source and the other (the 'side') at right-angles.

Discussion on whether stereophonic systems should be made compatible with monophonic brought forth the sobering analogy of a locomotive on legs. The fourth session included a review of recent developments in stereophonic-disc recording, cutting processes and the design of pickups. Dr. Dutton spoke of the standards being adopted and discussed the operation of the chosen 45/45 system.

Brains trust

It was decided to make the fifth and last session a 'brains trust' in which a panel took the stage under the chairmanship of J. Moir and the audience were in the happily ambivalent position of being able both to put questions to the panel and to comment on their answers. Mr. Moir lit the touch-paper by asking whether stereophony is worth while.

Answering this was not as straightforward as might have been expected, and it led to a discussion of the poor man's stereophonic effect or pseudo-stereo, obtained from a monophonic origin and two loudspeakers either ill-matched or combined with a phase-shifting mechanism. On the whole this was deprecated although it was admitted that many could not tell this from the real thing. Stereophonic equipment was as yet very expensive and it was better to buy high-quality monophonic than poor-quality stereophonic apparatus.

A few speakers complained that stereophonic sound produced strange discomforts between the ears, while others foresaw problems in adapting living-rooms to listening-rooms. Dr. Dutton however believed that since more information is fed to the brain less tension is felt when listening to stereophonic recordings. Another contributor considered that stereophony's most important feature was the enhanced clarity it gave, not merely the facility of identifying the position of orchestral instruments.

The 'dry' effect of the Kelvin Room which was used for demonstrations was praised by R. E. Cooke who said that the results were the best he had heard and suggested that it might be used as a standard.

G. Millington, the then Chairman of the Electronics and Communications Section which organized the convention, brought it to a close by thanking those concerned in its success including the demonstrators.

The proceedings of the convention comprising papers, contributions and discussions are now available in

The 'brains trust' in session

Seated at the table on the left are (l. to r.) D. G. Jaquess, F. H. Brittain and W. S. Percival; and on the right are (l. to r.) T. Somerville, G. F. Dutton, D. E. L. Shorter and J. J. Geluk. In the chair is J. Moir

supplement 14 to Part B of the *Proceedings*, price (post-free) 10s. to members, 17s. 6d. to non-members.

Summaries of papers

Survey of stereophony (*3150*) by T. Somerville, B.SC.

DEVELOPMENTS in microphone, transmission and loudspeaker techniques are discussed.

Survey of stereophony as applied to broadcasting (*3177*) by D. E. L. Shorter, B.SC.(ENG.)

THE survey covers compatibility and the application of stereophony to television.

Compressed-bandwidth stereophonic system for radio transmission (*3152*) by W. S. Percival, PH.D., B.SC.

LEFT and right microphone signals are combined to form a single a.f. signal and are also used to produce a signal of 100c/s bandwidth containing directional information which modulates a subcarrier at a power level much lower than that of the a.f. signal.

V.H.F. transmission of stereophonic programmes (*3153*) by J. J. Geluk, DR.TECH.

DISCUSSION is restricted to f.m. transmitters with a subcarrier system, and the superiority of the 'double f.m.' scheme is shown. The transmitter duplexer and the adaptor for ordinary f.m. receivers are described.

The adventure of building

THOROUGHLY to remodel an oldish building like that of The Institution while remaining in occupation calls for much patience and forbearance because it invites considerable inconvenience.

The Immediate Past-President may well have called it a little more than that when he heard at a recent committee meeting rumbles of more than usual sonority and on lifting his head to identify the sound was forthwith smothered in soot and dust. Indeed it was some time before the air cleared and he could identify his fellow nigger-minstrels! This dismal incident was caused by a brick dropping down one of the gross or more of ventilating flues which honeycomb the building's walls and forcing out through a grille the atmospheric deposits of 80 years or so.

Similarly a member of the E.D.A. staff was sprayed with cement spots from a ventilating shaft into the top of which a cheerful but rather mystified mason was pouring gallons of liquid cement grout and wondering where on earth it was all going to.

Disturbing the fish

Mischief having learnt from these achievements arranged an improved version when a large piece of stone broke into two in the mason's hands and cascaded down the chimney flue of the housekeeper's flat. This not only brought down several bushels more soot than the above-mentioned ventilator could produce but also shot the entire fireplace clean across the living-room.

Luckily it just missed the housekeeper's magnificent collection of rather startled tropical fish. She herself was hardly disturbed by the racket as her faculties had been dulled by the operation for the previous ten months of a heavy compressor outside her dining-room window as well as by the cacophonous chatter of pneumatic drills.

These noises are of course disturbing to the rest of the occupants of the building to a greater or lesser degree according to the proximity of the source. There is something faintly menacing about a pneumatic drill starting its growling work on the other side of a wall near which one happens to be standing.

However all the suffering is not on one side as the Builder will testify while ruefully rubbing the lump raised on his head by yet another fragment of wayward masonry. A plumber too was caught unawares when working on a disconnected waste-pipe outside the building. He received an earful of soapy water from a wash-basin used by a member who had ignored the 'out of order' notice—it is hoped inadvertently.

Instruments of consolation

It is not known whether incidents of this nature provoked one or two demonstrations on the part of the building operatives. One recalls the warning notice altered so as to refer to 'tall parsons' and the overheard reference to the Institution occupants as 'toffee-nosed'. One remembers too the crowning indignity suffered by Michael Faraday's statue. Displaced from the Library landing, standing forlornly on the floor outside the hive of building activity in the Lecture Theatre on the day before the General Election, he was seen to be firmly brandishing in his outstretched right hand a copy of a tabloid newspaper whose visible headline exhorted passers-by to vote for the party favoured by that journal.

The building itself has protested at the indignities inflicted on it by shedding lumps of the fabric from time to time, the worst example being the collapse of the plaster-coved ceiling in the Lecture Theatre which fortunately hurt no one. It has also been forced to reveal hidden weaknesses like the steel beam which was half eaten away by rust, and the broken water-main which had been leaking for who knows how long and washing away the subsoil.

Long-kept secrets have come to light in the shape of a rare old beer-bottle, well used clay-pipes and a pottery receptacle of indeterminate purpose. These were no doubt instruments of consolation and relief to an earlier generation of contractors in their harassed moments. No Roman or earlier relics have been found in the excavations, but a very old brick culvert which was uncovered may have been a drain from the ancient Palace of the Savoy. It got very much in the way of the new foundation work and had to be destroyed.

But there is no cause for alarm; the good old structure is fundamentally sound and extremely well built and has been lightened by the removal of 2000yd^3 of rubbish (a normal household's output for some 20 years) and about 250 tons of stone and brick embellishment. Furthermore it is well reinforced against mishap during the reconstruction by 18 miles of steel scaffolding held together by 22000 steel clamps, all supporting 17000 scaffold boards.

Travelling-wave resonance

A short article based on an Electronics and Communications Section paper (3031) entitled 'Some properties of travelling-wave resonance' by J. R. G. Twisleton, B.Sc., Associate Member. The paper was published individually in August 1959 and will be republished in Part B of the Proceedings. The author is with the British Thomson-Houston Co. Ltd.*

INTEREST has arisen recently in the properties of waveguide-ring circuits and cavities which are excited through directional couplers because of the phenomenon of travelling-wave resonance. Travelling-wave resonators have been found useful in such applications as the testing of microwave components at high power, feedback circuits for electron accelerators, and directional filters.

Travelling-wave resonators

Figs. 1b and 1c show two forms of travelling-wave resonator used by Milosevic and Vautey and others. These consist of a directional coupler and a length of waveguide connecting two arms of the coupler so as to obtain progressive waves in the loop. One remaining coupler arm is the input, and the other is terminated in a matched load. Fig. 2 shows an experimental ring-circuit of the Fig. 1b type with a two-slot coupler and a travelling probe for measuring the reflection in the ring.

The behaviour of this circuit may be described as follows: The input power is fed partly to the ring-circuit and partly to the load in accordance with the coupled-wave relations of Fig. 1a. Waves are launched directionally in the ring and show a resonant build-up when the ring length L is a multiple of the guide wavelength λ_g, owing to their arrival, after travelling round the ring, in phase with entering waves. Energy is stored in travelling waves, as compared with standing waves in ordinary waveguide resonators with reflecting ends.

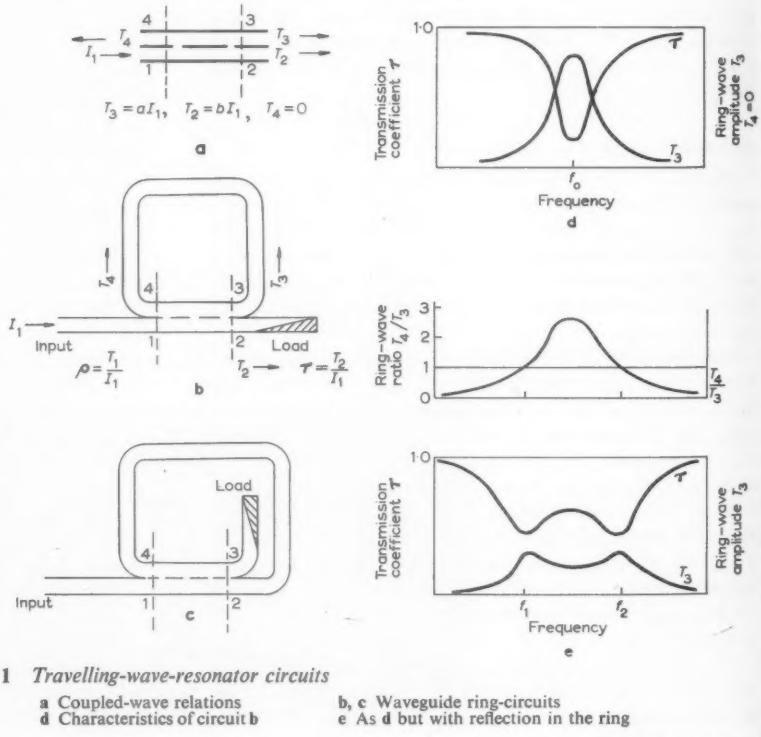
The variations in the ring-wave amplitude and that of transmitted waves are shown in Fig. 1d. These characteristics show how for example by the inclusion of a second directional coupler in the ring-circuit a directional filter can be obtained having stop and pass characteristics with separate outputs at the resonant frequency of the ring.

For both circuits we find that an optimum coupling exists which is dependent on the ring attenuation αL. With this coupling all the input power is fed into the ring at resonance, giving a power gain of $1/(2\alpha L)$ if the attenuation is small. For the circuit of Fig. 2 which is four wavelengths long at 3·2cm wavelength the calculated maximum gain was 200 and the half-power bandwidth 25Mc/s. A comparable energy storage can be obtained in ordinary resonators but the unique feature here is the travelling-wave condition.

Reflection in ring-circuits

In practical circuits which comprise many waveguide components reflection from any component must be cancelled by a reactor in the ring if travelling waves are to be obtained. Uncompensated reflection leads to the splitting of each ring resonance into two resonances which are usually slightly separated in frequency. Double-peaked responses in the ring-wave amplitude etc. are then obtained (Fig. 1e).

A standing wave is obtained in the ring at the resonant frequencies but the ring-wave amplitudes are unequal at other frequencies giving partial travelling-wave conditions. With a non-directional coupler standing waves are always obtained.



1 *Travelling-wave-resonator circuits*

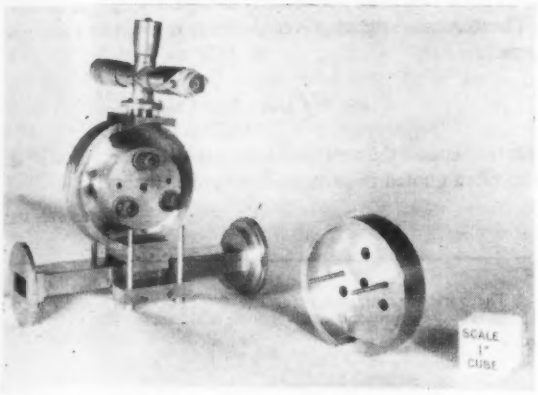
a Coupled-wave relations
b, c Waveguide ring-circuits
d Characteristics of circuit b
e As d but with reflection in the ring

* This article and those following are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers

Unequal propagation coefficients

When an electron accelerator or ferrite device is included in the ring-circuit the wave-propagation coefficients may be different for oppositely travelling waves. Two effects are considered in the paper, attenuation and phase shift of one travelling wave. With phase shift of one wave travelling-wave conditions can be obtained even with reflection in the ring because resonance of the oppositely travelling waves occurs at different frequencies.

Theoretically the effect of directional attenuation is to counteract the frequency splitting caused by reflection, and so in this case travelling-wave conditions are also possible.



2 *Experimental ring resonator with travelling probe*

Travelling waves in magnetrons

Finally it is of interest to note a similarity between the excitation of waves in a slow-wave circuit by an electron beam and by a directional coupler in the ring-circuit. In some electron devices backward waves induced in the circuit by the electrons cancel and forward waves add as a result of the beam/circuit-wave synchronism condition.

Travelling waves have been observed in magnetrons oscillating in non-π modes even with circuit reflections caused by strap breaks. While the analogy with the ring-circuit is not exact the study of travelling-wave resonators may help towards an understanding of the more complicated travelling-wave phenomena in the magnetron and other valves.

621.372.832.43.015.4

Travelling-wave parametric-amplifier theory

A short article based on two Electronics and Communications Section papers (2991 and 3017) entitled 'Theory of the travelling-wave parametric amplifier' by Prof. A. L. Cullen, Ph.D., Member, and 'Saturation effects in a travelling-wave parametric amplifier' by A. Jurkus, B.Sc., and P. N. Robson, B.A., Associate Member. The papers were published individually in August 1959 and will be republished in Part B of the Proceedings. Prof. Cullen is Professor of Electrical Engineering, University of Sheffield, and Mr Jurkus and Mr. Robson are in the same department.

THE principle of parametric excitation of circuits has been discussed a great deal recently, the usual starting-point being an LC circuit in which the capacitance is varied periodically at twice the natural frequency of the circuit and growing oscillations at the natural frequency result.

The development of this basic mechanism of power transfer to more sophisticated devices has been rapid but until quite recently attention has been concentrated on lumped-circuit amplifiers. These prove to be rather narrow-band devices and it is a natural step to consider travelling-wave variants of the lumped-circuit amplifiers. One would expect by analogy with klystrons and travelling-wave tubes that the travelling-wave parametric amplifier would be a relatively broad-band device, and such is the case in theory and practice.*

Saturation at high signal levels

There are however certain other properties which parametric travelling-wave amplifiers have in common with travelling-wave tubes and the main purpose of the two papers on which this article is based is to discuss these phenomena. We shall here discuss only one of these—saturation at high signal levels.

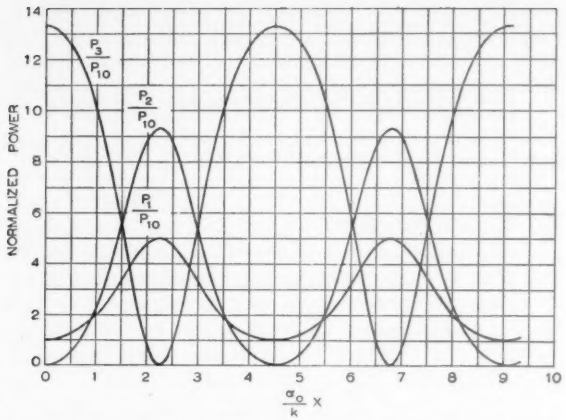
The parametric travelling-wave amplifier considered here consists of a transmission line with a capacitance per unit length which depends on the voltage applied through a linear relationship of the form $C = C_0(1 + \eta v)$ where η is a small quantity and v is the applied voltage. A relatively large power P_3 at a frequency f_3 higher than the signal frequency f_1 is supplied to the input end of the line, and the output end is assumed matched.

In small-signal conditions the signal wave will grow exponentially as it progresses along the line. It is obvious that amplification of the signal wave can occur only at the expense of the amplitude of the pumping wave. Ordinarily, perhaps indeed in most cases of practical interest, the signal-wave power will be so small in comparison with the pumping-wave power that this effect is negligible but this is not necessarily so. Fig. 1 relates to the case where this approximation cannot be made and shows how the signal power P_1 varies with position along the line. A remarkable cyclic behaviour will be noticed.

At the input end of the line the pumping power P_3 is large, the signal power P_1 is relatively small, and the idling-wave power is zero. As the pumping and signal waves progress they interact in the non-linear capacitance to produce sum and difference frequencies. (It is assumed that the sum frequency can be neglected owing to its markedly different phase velocity and/or high attenuation.)

The difference-frequency wave ($f_2 = f_3 - f_1$) called the 'idling' wave increases in power as the signal increases in

* Since the paper was written experimental results on a travelling-wave parametric amplifier have been reported by Lombardo and Sard and the broad-band property has been verified (*Proceedings of the Institute of Radio Engineers*, May 1959, p. 995)



1 *Variation of signal, idling and pump powers with distance along a parametric amplifier*

P_1 = signal power; P_2 = idling power; and P_3 = pump power. P_{10} is the signal power at the input and P_{30} the pump power at the input.
The corresponding pump voltage at the input is v_{30}. The phase-change coefficients of the pump and signal waves are β_3 and β_1 respectively.

$$\alpha_0 = \frac{\pi v_{30}}{2}\sqrt{[\beta_1(\beta_3 - \beta_1)]}; \quad k = \left(1 + \frac{\beta_3}{\beta_1}\frac{P_{10}}{P_{30}}\right)^{-1/2}$$

power. The signal- and idling-wave powers are extracted from the pumping wave which therefore decreases in level, ultimately falling to zero at the point of maximum signal power. Beyond this point the process is reversed and the signal and idling waves feed power back into the pumping wave, and so the process continues periodically along the length of the line.

The maximum signal power available is given by the simple formula:

$$P_{1\,max} = P_{1\,input} + \frac{f_1}{f_3}P_{3\,input}$$

This is of course the well known Manley–Rowe relation which is so often quoted in parametric-amplifier theory.

621.375.9 : 621.372.2

The variations of power for the three waves are given by the following expressions involving elliptical functions:

$$P_1 = P_{10}nd^2\left(\frac{\alpha_0}{k}x\right)$$

$$P_2 = \frac{\beta_3 - \beta_1}{\beta_1}P_{10}k^2sd^2\left(\frac{\alpha_0}{k}x\right)$$

$$P_3 = P_{30}cd^2\left(\frac{\alpha_0}{k}x\right)$$

The Figure is drawn for the case $f_1/f_3 = 0{\cdot}3$

Ferromagnetic travelling-wave amplifiers

A brief article based on an Electronics and Communications Section monograph (334) entitled 'The gain of travelling-wave ferromagnetic amplifiers' by P. J. B. Clarricoats, B.Sc.(Eng.), Ph.D., Graduate. The monograph was published individually in May 1959 and republished in Vol. 106, Part C, p. 165, of the Proceedings. It was read at Savoy Place on the 9th November 1959 before the Section.

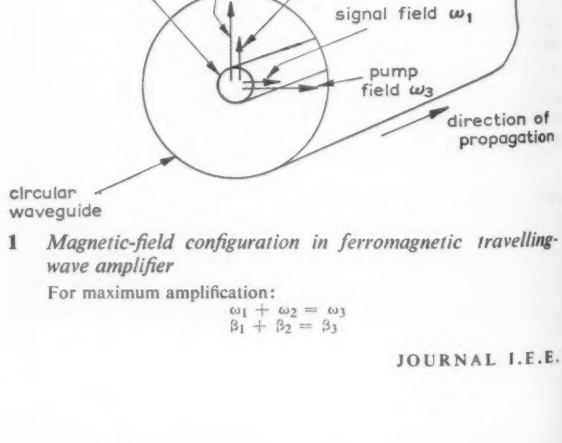
In the last two years a number of workers in the United States and the United Kingdom have studied experimentally the performance of microwave parametric amplifiers employing ferromagnetic materials in resonant cavities. In these the ferromagnetic material, either a ferrite or garnet, provides regenerative coupling between microwave magnetic fields at two frequencies. One field is excited by the signal and the other is excited naturally.

For amplification to occur energy produced by the periodic coupling of the signal and idler fields must be sufficient to overcome the losses in the cavity. The coupling is provided by placing the ferromagnetic material in the microwave magnetic field of a high-power local oscillator or pump, the frequency of which must be equal to the sum of the signal and idler frequencies.

The ferromagnetic material is therefore placed in a position in the cavity where it can interact with signal, idler and pump magnetic fields simultaneously. For operation the cavity must be resonant to the signal and idler frequencies and for maximum efficiency to the pump frequency also. In addition a static magnetic field must be applied to the material so that ferromagnetic resonance occurs at the pump frequency.

Cavity ferromagnetic amplifiers

The advantage to be expected from such an amplifier is a low noise factor. This follows because, the magnetic material being an insulator, there are no 'free' electrons as in electron-beam amplifiers of the klystron or travelling-wave-tube type. While similar low-noise properties might be expected in masers the disadvantage there is the need to provide a liquid-helium environment for the active amplifying material. Ferromagnetic amplifiers operate quite satisfactorily at room temperature. The disadvantage of the ferromagnetic parametric amplifier lies in the narrow bandwidth of amplification. This corresponds to that of the signal–idler cavity.



1 *Magnetic-field configuration in ferromagnetic travelling-wave amplifier*

For maximum amplification:

$$\omega_1 + \omega_2 = \omega_3$$
$$\beta_1 + \beta_2 = \beta_3$$

Travelling-wave ferromagnetic amplifiers

If alternatively the coupling were distributed along a travelling-wave structure, such as a waveguide, and the signal, idler and pump waves allowed to propagate simultaneously a wideband amplifier should be realizable. Such a structure is shown in Fig. 1. A ferrite or garnet rod is supported on the axis of a circular waveguide, and the rod is magnetized in a direction normal to that of propagation. The waveguide radius is chosen so that signal, idler and pump waves can propagate simultaneously.

For maximum amplification it is necessary that the frequencies and phase-change coefficients satisfy $\omega_1 + \omega_2 = \omega_3$ and $\beta_1 + \beta_2 = \beta_3$ respectively. In practice it would probably be necessary to load the waveguide in order to satisfy the latter condition. As before, the static field must be adjusted so that the rod exhibits ferromagnetic resonance at the pump frequency.

The orientation of the axial microwave magnetic fields is also shown in Fig. 1. In the absence of the pump the signal and idler fields are uncoupled. However when the pump is applied the fields are coupled to form a pair of joint signal and idler modes. The attenuation coefficients of these modes depend on pump power level. As pump power is raised one coefficient decreases while the other increases. Eventually at a certain power level one of the attenuation coefficients changes sign and the amplitude of the corresponding joint signal and idler mode increases with distance along the waveguide. Amplification is therefore achieved.

Although analysis suggests that quite high gain per unit length could be obtained with such an amplifier a considerable amount of pump power must be dissipated in the ferromagnetic rod. Thus in practice there seems very little likelihood of operating a travelling-wave ferromagnetic amplifier of the type described above as a continuous device. However while applications may exist where pulsed amplification could be useful there seems justification for studying ferromagnetic amplification processes in which the locally applied pump field does not excite ferromagnetic resonance. 621.375.9 : 621.372.85

Classification of waveguide modes

A short article based on an Electronics and Communications Section paper (3132) entitled 'Some comments on the classification of waveguide modes' by A. E. Karbowiak, B.Sc.(Eng.), Ph.D., Associate Member. The paper was published individually in October 1959 and will be republished in Part B of the Proceedings. *The author is with Standard Telecommunication Laboratories Ltd.*

THE oldest guiding systems are the twin-wire transmission line and the coaxial cable. Although voltage and current are the physical variables of greatest interest at low frequencies the concept of waves is more useful at high frequencies. The wave guided by such structures is transverse electromagnetic (TEM) and its existence is well established by numerous experiments.

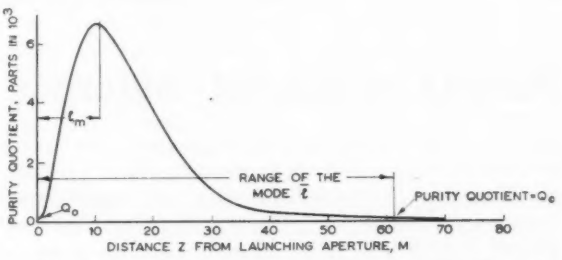
At much higher frequencies (microwaves) waveguides are the common means of transmission and a hollow pipe is a notable example. Again with such waveguides the reality of guided waves is on available experimental evidence beyond dispute.

However with surface waves (a mode of guided wave on the outside of a suitable conductor) the proof for or against their existence is not so easy to produce, and in fact resort has had to be made to theoretical analysis to help resolve accumulating doubts. Such studies are commonly carried out against the background of approximations, and not infrequently conflicting conclusions have been reached by various investigators.

The paper presents a discussion of known facts and a modified classification of modes based on suitable definitions. It is pointed out that conclusions depend to a large extent on assumptions and definitions made at the beginning, but there is no purpose in making assumptions or avoiding definitions if this leads to no useful conclusions or conflicting physical pictures.

Proper-modes and quasi-modes

With perfect (lossless) waveguides (mathematical ones) the concept of a 'proper-mode' is a useful one since the proper-mode of a guided field is similar to a Fourier component of alternating current.



1 *The purity quotient as a function of distance from the launching aperture in the presence of a radiation field*

It is assumed that power in the guided mode is directly proportional to exp $(-\alpha z)$ and that in the radiation field to z^{-2}
Constants of the guiding structure are:
Q_0 = launching purity quotient = 10
α = 0·1 neper/m

With imperfect (physical) waveguides the concept of a 'quasi-mode' is advocated. This is a component wave of a field that can exist in a waveguide with surface-impedance boundaries, i.e. an attenuated wave whose field components are proportional to exp $(j\omega t - \gamma z)$ where γ is the propagation coefficient and z the axial distance. The modes commonly known to exist in coaxial cables or twin-wire transmission lines are quasi-modes, and proper-modes are special cases of these.

It is shown that surface waves are also quasi-modes but whereas a mode in a closed waveguide can exist in a very pure

form a surface wave is frequently very contaminated because the surface waveguide is an open structure and launching devices are usually inefficient. The difference here however is quantitative and not qualitative.

If the purity of any mode in or on a physical waveguide is plotted against the axial distance a curve similar to that in Fig. 1 is obtained. It transpires that although a mode may be very pure over a central range it will be unrecognizable outside this range ($\bar{l}$ in Fig. 1). This applies to all waveguides whether closed or open, but whereas for a tubular waveguide this range may be of the order of miles for a surface waveguide it may be of the order of a few feet only, or less.

The validity and usefulness of the concept of modes in general and quasi-modes in particular take up a large proportion of the paper while the meaning of existence of modes is discussed in some detail. It is shown that much of the controversy about the existence of modes (in particular surface waves) is meaningless unless we start with clear definitions—which has not been observed in the past.

Conclusions

The important conclusions are:

1. Proper-modes though useful in some applications do not exist on any physical structure.
2. Quasi-modes may not always exist in a very pure form but are an important concept. In many physical situations a quasi-mode may be almost the sole constituent of the field.
3. Physically what usually exists is a field configuration whose nature and variation with the axial distance z from the launching source are functions of the type of antenna, the geometry and structure of the waveguide, as well as of the surface impedance of all waveguide walls. Any field can be conveniently expanded in a series of quasi-modes and the radiation field. A resolution of this kind however is largely arbitrary and the only justification for such a procedure is convenience. Such is the case for example if over the range considered the field resembles very closely a particular mode; over that range the mode is said to exist in a substantially pure form despite the fact that at distances considerably outside this range the field bears no resemblance to the mode considered (Fig. 1). In fact there can be little or no meaning ascribed to the existence of a mode unless the range is finite and specified.

It is because frequently a quasi-mode is almost the sole constituent of the total field (in the range of interest) that a classification in terms of quasi-modes is justified. On the other hand with some structures (frequently surface waveguides) there may be no useful finite range over which the field would approximate to the field of any quasi-mode and in such cases it is meaningless to discuss existence of modes.

In general we must take a practical engineering approach. If a mode is suspected to be present in the total field but with a very small amplitude one may as well assume that the mode does not exist since the coupling between two antennas separated by a finite distance would in the circumstances be almost entirely due to the remainder of the field (say radiation). A more precise inquiry is of little significance because the outcome is solely dependent on convention.

621.372.81.09

Permanent-magnet materials

A short article based on a Measurement and Control Section paper (3069) entitled 'Progress in permanent-magnet materials' by J. E. Gould, B.Sc., F.Inst.P. The paper is published this month in Part A of the Proceedings. The author is with the Permanent Magnet Association.

THE behaviour of the permanent-magnet materials now in use and the possibilities of those under development can be adequately described only in terms of magnetic-domain theory. According to this well established theory the characteristic shape of the normal hysteresis loop is an indicator of the movement of domain boundaries and of the rotation of individual domain magnetization under the influence of applied fields.

Within each domain there is a state of saturation magnetization in some axes, but only for very large external fields are the domain magnetic axes all parallel.

In these terms the requirement for a good permanent-magnet material is that it should contain, without reducing unduly the proportion of basic magnetic material, the best possible barriers to domain-boundary movement by way of strains, precipitates or heterogeneities of structure. As a homogeneous magnetic particle is reduced in size a stage is reached at which it is no longer energetically favourable to subdivide the magnetization axes to multiple domains and then the single magnetization axis is moved only by strong opposing magnetic fields. At some critical field value determined by crystal characteristics and particle shape there is a sudden reversal of magnetization—the particle has a substantial coercive force.

Thus the production of a permanent magnet involves subdivision of the basic magnetic material into unit domains of critical size and shape, by controlled metallurgical precipitation in the commonly used alloys but by altogether different methods in some of the newer materials. The critical dimensions involved are in the range 0·02–1 μ.

Ni–Al–Co–Fe alloys

The prototype for the most widely used permanent-magnet material is an alloy with about 13% nickel, 8% aluminium, 24% cobalt, 3% copper, and the balance iron. Small amounts of other elements such as niobium, silicon, titanium and zirconium are used by different manufacturers to vary the properties. The coercive force and hysteresis-loop shape are changed considerably by heat-treatment although the saturation magnetization (about 14 000 gauss) varies little.

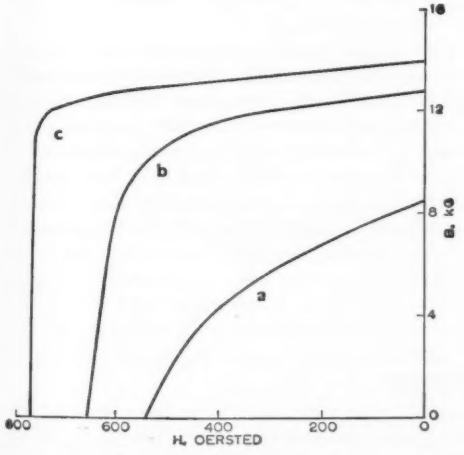
In particular the application of a strong magnetic field during controlled cooling from over 850°C gives a very

Table 1. Characteristics of typical permanent-magnet materials

Composition weight % (balance Fe)	Production method	Name	B_r gauss	$(BH)_{max}$ 10^6 gauss-oersteds	H_c oersteds
(a) Widely used alloys					
14Ni, 8Al, 24Co, 3Cu	columnar casting	Columax Ticonal GX	13500	7·8	750(A)
as above	cast or sintered	Alcomax II, III, IV Ticonal C, E, G Alnico 5, 6	10000– 13000	4–6	800–600(A)
18Ni, 10Al, 12Co, 4Cu	as above	Alnico Alnico 2	6500– 8000	1·7	670–500
25Ni, 12Al, 0·3Cu	as above	Alni Alnico 3	5000– 6500	1·25	680–480
(b) Steels (obsolescent)					
35Co, 6Cr, 5W, 0·9C	cast or rolled bar	35% Co-steel	9000	0·95	250
3, 9 or 15Co, 9Cr, 1Mo, 1C	as above	Co-steel	7200– 8200	0·35–0·62	130–180
3 or 6Cr, 0·9C	rolled bar	Chrome steel	9800	0·28	70
(c) Oxide materials					
$BaO.6Fe_2O_3$	sintered ceramic	Feroba 2 Magnadur 2	3800	3	1700(A)
as above	as above	Feroba 1 Magnadur 1 Caslox II	2100	1	1750
as above	resin-bonded compact	Caslox III	1500	0·45	700
(d) Miscellaneous special materials					
77Pt, 23Co	forged or rolled	Platinax	6500	9	4000
79Bi, 21Mn	pressed compact	Bismanol	4300	4·3	3400 (A)
52Co, 11V	rolled or drawn	Vicalloy	9000	1	300
17Mo, 12Co	cast, rolled or sintered	Comalloy	10500	1·1	230
Fe particles with bond	pressed	E.S.D.	8800	3·3	715(A)
FeCo particles with bond	as above	as above	9050	5	1025(A)

A = anisotropic, properties for preferred axis given

square hysteresis loop when measured in the axis of the field treatment and a very lean loop when measured in perpendicular axes. This squaring of the loop during field treatment is increased if the cast grain-structure is of a columnar type so that one of the major crystal axes of each grain also coincides with the field-treatment axis. The different demagnetization curves resulting from these treatments are shown in Fig. 1 and the production alloys are listed in Table 1.



1 *Effect of field treatment and grain-structure on demagnetization curve for alloy of composition 14%Ni, 7·5Al, 25Co, 3Cu, 0·7Nb, balance Fe, cooled from 1250° C and tempered at 590°–560° C*

a Random grains—no magnetic field in heat-treatment $(BH)_{max} = 1·75 \times 10^6$ gauss-oersteds
b Random grains—heat-treated in field $(BH)_{max} = 5·4 \times 10^6$ gauss-oersteds
c Columnar grains—heat-treated in field $(BH)_{max} = 8·7 \times 10^6$ gauss-oersteds

Such magnetic field treatment is effective only for alloys of high Curie point, which necessitates high content of cobalt. When the magnet application does not lend itself to a single magnetic axis, isotropic properties roughly as curve a in Fig. 1 can be obtained without field treatment, but at less cost by reducing cobalt content and modifying the remainder of the composition (see Table 1).

In all these alloys it is now clear that the controlled cooling from high temperature gives rise at about 800° C to a two-phase structure with submicroscopic plates or rods of a strongly magnetic phase within a weakly magnetic one. The plates are aligned along the cubic crystal axes of the materials; if a field is applied during cooling, plate formation is suppressed in axes perpendicular to the field provided that the composition is such that the nucleating plates are magnetic at the temperature at which they are formed.

Subsequent tempering is needed to control the best size and composition of the two phases, which then gives an array of strongly magnetic single-domain elongated particles which retain a high proportion of the magnetization imposed by a saturating field even under the influence of reverse fields until a critical value is reached.

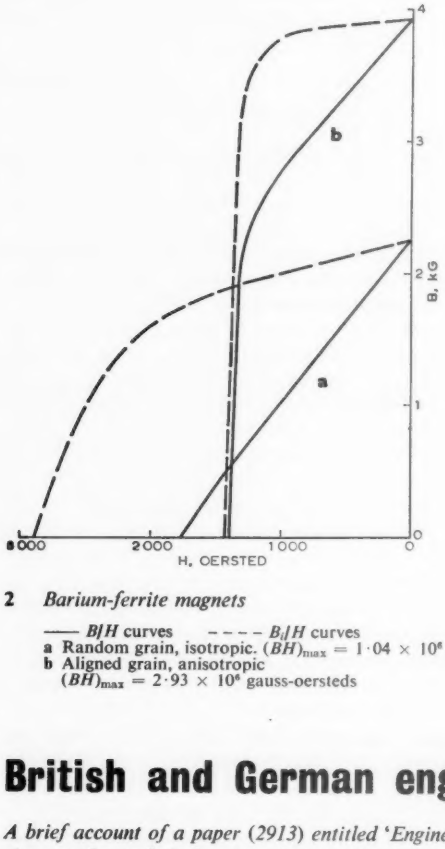
Permanent magnets in these alloys are usable, subject to small magnetization losses, between −100° and 500° C. The same alloys with only slightly differing characteristics can be produced as normal foundry castings or by the powder-metallurgy techniques of compacting and sintering. Despite difficult mechanical properties the great majority of permanent magnets throughout the world are now produced in the

Ni–Al–Co–Fe alloys, both for a steadily increasing range of electromagnetic applications and for a rapidly developing number of holding devices and similar mechanical uses.

Other magnet materials

The commercial use of the magnet steels based on iron–carbon and other elements is decreasing steadily as apparatus is redesigned but they still have their economical uses for small magnets of relatively complex form. Table 1 summarizes the properties of the standard types.

In recent years an entirely different class of materials has been prominent—ceramic-like sintered oxides somewhat analogous to natural lodestone, the original permanent magnet. Although several similar compounds are known the main development has been of barium ferrite, chemically $BaO.6Fe_2O_3$. This is a magnetic oxide of low saturation magnetization (about 4600 gauss) but with a hexagonal-type crystal with high inherent magnetic anisotropy.



2 *Barium-ferrite magnets*

—— $B|H$ curves - - - - $B_i|H$ curves
a Random grain, isotropic. $(BH)_{max} = 1{\cdot}04 \times 10^6$ gauss-oersteds
b Aligned grain, anisotropic
$(BH)_{max} = 2{\cdot}93 \times 10^6$ gauss-oersteds

Manufacture involves formation of the compound, milling to a fine powder, compacting under pressure, and sintering at 1200°–1300°C under careful control so as to obtain a sintered mass in which the average crystal size is that for single-domain behaviour. In an improved variety the powder particles are aligned by a magnetic field during pressing, giving the higher remanence and fuller demagnetization curve characteristic of other anisotropic materials.

In the use of these materials it is essential to keep in mind the difference between the curves for field against intrinsic magnetization and against normal induction. These differences and typical values are shown in Fig. 2. The high coercive force is advantageous for some applications but the temperature coefficient of magnetization is about ten times higher than for alloy magnets and there are other temperature changes which make the material unsuitable for measuring apparatus.

An interesting variant of the sintered compacts is produced by preforming the fine powder and then bonding with a plastic or natural rubber, resulting in a material of very low energy but extremely resistant to demagnetization. Typical magnetic values for the three varieties are given in Table 1.

There remain a number of magnet materials of technical interest but limited commercial application. A cobalt–platinum alloy in equi-atomic proportions gives remarkably high energy and coercive force and is still not clearly understood. Manganese–bismuth forms a compound with high crystal anisotropy and, by compacting crystals of critical size, gives magnets of high energy but with temperature limitations similar to those of barium ferrite. Cobalt–vanadium–iron and cobalt–molybdenum–iron alloys have useful intermediate magnetic properties combined with better mechanical properties than those of other materials but are not likely to find a wide field of application.

Finally there is much current development work, and great possibilities are foreseen in the chemical or electrolytic preparation of iron powders, with the correct shape and size to give single-domain behaviour, capable of compaction to aligned bodies with anisotropic properties very similar to those of the nickel–aluminium–cobalt–iron alloys. Limited production has commenced in the United States but the economics of the process are not yet established and the ultimate limit of properties now seems to be much lower than was at first thought.

621.318.22

British and German engineering degrees

A brief account of a paper (2913) entitled 'Engineering education at the technical universities in Western Germany' by D. B. Welbourn, M.A., Member, D. B. Spalding, M.A., Ph.D., and G. L. Ashdown, Member. The paper was published individually in May 1959 and is republished this month in Part A of the Proceedings. Mr. Welbourn is Dean of Selwyn College, Cambridge, and University Lecturer in Engineering; Dr. Spalding is Professor of Heat Transfer, Imperial College of Science and Technology, University of London; and Mr. Ashdown is Senior Lecturer, Battersea College of Technology, London. The paper was presented at a Joint Meeting with The Institution of Mechanical Engineers at Savoy Place on the 28th May 1959.

THE rapid development of technological education in Great Britain during recent years has been accompanied by continuous and vigorous discussion of the best methods of educating and training engineers, and the comment has often

been made that we ought to model at least a part of our development on the German technical universities (Technische Hochschulen).

The Lord President of the Council, who is responsible for the work of the University Grants Committee, therefore decided that a detailed comparison ought to be made of the standards reached by men studying at universities and colleges of advanced technology in this country and those attained by men studying at technical universities in Germany. With the aid of the Foreign Office a small team from Cambridge, Imperial College and Battersea College of Technology visited Germany last year, and later in the year a return visit was made by a team of professors from the German technical universities. The paper summarizes their factual findings and the comparisons and conclusions which they drew.

The proper stage for comparison

Each team found much to envy in the system of education in the other's country but the general conclusion reached was that although the methods of education are very different the young engineer who emerges is very similar in each country if the proper comparisons are made.

The German student spends an average of five years at the university in the course of which he spends a total of 12 months in workshops. When he achieves his degree, which will normally be at the age of 24½, he will have received a very large amount of formal instruction in design and current practice which the British universities make no attempt to impart since in Britain the student is expected to spend three years at the university and then to do a two-year graduate apprenticeship which he will normally finish at the age of 23½. The point then at which the products of the two systems should be compared is five years after they have left school.

The British team reached the rather tentative conclusion that the British system was perhaps better for the really good man, the German for the average one. They also thought it possible that the British student would have a better analytical grounding and be more familiar with running machinery while the German student would be much more at home in design work and in the development laboratory.

A less specialized future

Of particular interest to electrical engineers is the fact that the big electrical firms in Germany are putting great pressure on the technical universities to teach electrical engineering in a far more general manner than is normal at present. As a result Aachen have now instituted a course in electrical engineering in addition to their two existing courses in light-current and heavy-current engineering, and at least one other technical university is considering the possibility of running only one course in the future.

Perhaps the most interesting discovery was to find how many German professors are envious of our system of engineering education and that two German universities are seeking to add technological faculties. At the same time several of their technical universities, and notably Berlin, are developing strong arts faculties so as to become not merely *technical* universities but universities. 62.378.1

Problems of engineering education

A brief account of a report (2987) with the above title by Profs. H.-G. Kayser, K. Luerenbaum, Cl. Müller, R. Sauer, H. Stefaniak, and R. Wille. The report was published individually in May 1959 and is republished this month in Part A of the Proceedings. Profs. Kayser and Wille are at the Technische Universität, Berlin; Profs. Luerenbaum and Müller at the Technische Hochschule, Aachen; and Profs. Sauer and Stefaniak at the Technische Hochschule, Munich. Prof. Wille who prepared this account on behalf of his colleagues states that many of the views expressed in it are purely his own. The report was presented at a Joint Meeting with The Institution of Mechanical Engineers at Savoy Place on the 28th May 1959.

The demand for more and better training facilities for technologists and engineers has led to many visits and conferences between British and German university teachers. German interest has been caught equally by the remarkable expansion and modernization of the traditional university faculties and by the successful setting-up of the new colleges of advanced technology.

The German Technische Hochschulen with their courses leading to the academic degree of Dipl.-Ing. have a twofold task: to teach the basic sciences of engineering and to provide a great variety of practical courses. The professional institutions or their equivalent are not known in Germany; the Dipl.-Ing. degree signifies professional as well as academic qualification.

The advantage of the German system is that the engineering student leaving the university has already gained some knowledge of the problems he will have to face in industry. For many industries with medium-sized factories the young Dipl.-Ing. has full earning capacity after an astonishingly short time. In consequence the German system requires that at least 50% of the university teachers be recruited from industrial careers. This is one of the reasons why all German academic teachers are 'professors'—a man with 15 to 20 years' industrial experience cannot be tempted to enter a university career without being given the status and the salary of a professor!

Lectures the keystone of teaching

At German technical universities the lectures are the keystone of teaching, and these are by tradition the responsibility of the professors alone. The idea is that the professors give their students a contact with theory and its applications in their own individual ways and based on their own research.

On the other hand the German system makes considerable demands on both teaching staff and students. As professional training is an integral part of the studies it is up to the professor to keep pace with the problems of industrial research, development and production. The students have to spend five years or more before gaining a degree and during the last two years specialization is more or less unavoidable.

Distribution of responsibility

It is rather difficult to decide whether the English or the German system is better suited for future demands. If we believe that a student's time at the university should not be extended and if we still hope to be able to educate 'all-round' engineers the German system will soon meet with great difficulties. The English system appears more adaptable to the demands of a quickly changing world because the responsibility is more evenly distributed between the schools of higher learning (universities and colleges of advanced technology), industry and the professional institutions.

62.378

Electronics in jet-engine control

A brief article based on a Graduate and Student Section paper entitled 'The application of electronics to jet-engine control' by H. E. Coles, B.Eng., Graduate. The paper was read before the London Graduate and Student Section at Luton on the 20th November and at Savoy Place on the 9th December 1958. It was awarded a premium by the Council. The author was formerly with the de Havilland Engine Co. Ltd. and is now in the Department of Electrical Engineering, Brunel College of Technology, Acton.

The gas turbine of today which is capable of powering aircraft at supersonic speeds and at very high altitudes requires exceedingly complex associated controls. The present basic engine-regulation system aims at reducing the anxiety of the pilot and leaving him free for other duties particularly in military aircraft during combat. Many of the engine variables which have to be adjusted continually in flight can be controlled automatically without the human operator.

Some of the principles governing the choice of regulating system are outlined here and it is shown how with the aid of electronics these controls and their many features have been evolved.

Early regulation

The direct control of thrust in both centrifugal and axial compressor engines is by fuel input. The quantity of fuel that the engine requires in order to run at constant speed is a function of speed, compressor-inlet pressure and temperature. A fuel system must therefore be sensitive to these parameters, with fuel flow usually adjusted by the pilot's throttle lever according to some preset law. As an aircraft changes its altitude and forward speed the fuel flow must be compensated accordingly for variations in the ram-intake pressure and temperature.

Early turbojet control utilized a manually operated throttle valve which was adjusted to provide the fuel flow needed for a particular engine speed. A later refinement was added so that varying engine-fuel requirements at high altitudes could be met. A bypass valve was actuated by a mechanical barometric-pressure control (b.p.c.) which sensed altitude pressure and reduced fuel flow to the engine at high altitudes. To prevent the engine stalling and to avoid temporary overfuelling during rapid acceleration a mechanically operated air/fuel ratio governor was fitted to override the b.p.c., the fuel flow to the engine being reduced by altering the fuel-pump stroke.

Present-day control

Should the turbine temperature tend to rise above the safe allowable value it is necessary to apply a fully automatic temperature trim. This, known as the electric pressure control, senses overheating by means of thermocouples placed in the jet pipe, and a pump servo-valve operated via a magnetic amplifier alters the pump stroke which governs the fuel flow to the engine.

Another reliable and accurate feedback control is obtained by means of an electrical automatically compensated speed regulator which ensures that the maximum engine speed is not exceeded in any flight condition. This control trims the engine-fuel flow via an electrically operated servo-valve according to the output signal from a three-stage magnetic amplifier. The amplifier input is fed from an engine-driven tachogenerator which gives an a.c. output of frequency and voltage proportional to the number of revolutions per minute. At an engine speed above the chosen balance-point on an r.p.m. datum selector a signal is produced which cuts down the flow of fuel to the engine.

At 23000ft an altitude-compensating unit begins to respond to the variation in ambient pressure and biases the first stage of the amplifier. It provides a further change in servo-valve setting to cut down engine-fuel flow, thereby reducing the turbine speed which holds the jet-pipe temperature at its maximum safe value.

The turbojet with reheat

Reheat is a method of obtaining extra thrust from a jet by injecting additional fuel downstream of the turbine in the tailpipe. It is carried out without affecting the running conditions of the main engine. To govern the amount of reheat a fully variable nozzle area is essential.

In the reheat section the additional fuel is scheduled according to some preset law by the thrust selector or pilot's throttle lever. The variable-nozzle regulator can be linked to this selector by means of synchros or magslips which operate a hydraulic servo-valve providing the oil flow to the hydraulic actuators which vary the final nozzle area.

Should the nozzle and the fuel get out of step certain

temperature and speed overriders are provided. Override signals supplied by electric sensors are fed to an electronic amplifier whose output current controls the field of an a.c. motor. The motor moves the servo-valve which regulates the flow of oil to the hydraulic actuators.

Integrated control

The electronic regulators so far envisaged are merely trims on the normal operating controls and it would be desirable to achieve a fully integrated system. It is possible to employ the electronic medium on a fully variable-geometry engine to feed all the engine and aerodynamic conditions to a central computing unit which in turn monitors the control signals. In the United States an early integrated electronic scheme used on an operational aircraft governed the engine speed within very close limits in all flight conditions.

Variable-intake regulation

The jet engine consumes a fixed quantity of air per second in fixed ambient conditions. However if the engine is to run at full capacity for any Mach number and altitude a variable intake is required. This varies the cowl shape so as to give a good pressure recovery and does so by an electrically actuated closed-loop position control of a movable centre-body with a spiked tip. This tip produces an oblique shockwave which is correctly positioned at the cowl lip.

Normal shockwave position sensed by pressure tappings inside the cowl lip is the input to the system. Pressure is converted to a voltage amplified by a transistorized amplifier whose output current drives an electric motor which actuates a mechanical jack-screw carrying the centre-body.

Future trends

The development of aeroplanes and engines to fly in the stratosphere at high speeds introduces a thermal problem and an interaction problem. When the ram-air temperature exceeds 150° C many electronic components cannot be used unless forced cooling is applied to them. Recent developments enable some components to be used at quite high temperatures without cooling.

With many engine closed-loop regulators acting together it is quite possible that during a transient one of the control loops may have an unstabilizing influence on another. A study of the regulating elements on the engine must be made using the servomechanism approach so that instability can be avoided.

629.135:621.438:621–52

Speed control of squirrel-cage induction motor

This article is based on a Graduate and Student Section paper entitled 'Novel methods of speed control applied to a standard 3-phase squirrel-cage induction motor' by G. K. Creighton, B.Sc., Student, and W. M. Somerville, Graduate. The paper was read at Bristol before the Bristol Graduate and Student Section on the 12th February 1958 and it was awarded a premium by the Council. The authors are at the University of Bristol.

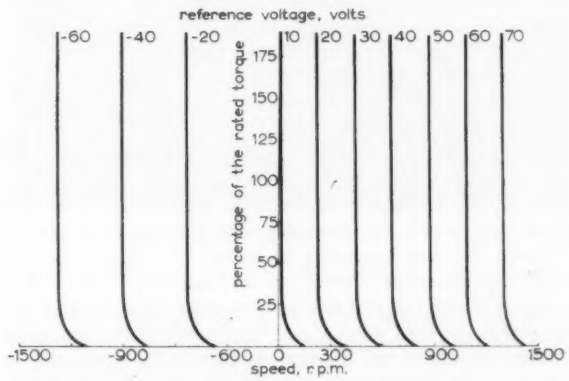
VARIOUS methods of stabilizing the speed of an induction motor have been described in the United States and the Soviet Union all of which depend on the same principle—although this is not immediately clear from the published accounts. The present paper describes two methods of stabilizing the speed of an induction motor at any point between standstill and the synchronous speed, one method being employed to demonstrate the basic principle and the other being new.

The principle

Stable operation of an induction motor and load is possible only when the slope of the torque/speed curve of the load is greater than that of the torque/speed curve of the induction motor at their point of intersection; this is a condition which is usually satisfied for values of slip near zero.

However the induction motor can be made to run stably in normally unstable conditions by automatic control of the voltage applied to the stator windings; i.e. when the speed of the motor tends to increase, the voltage and hence the torque are decreased and vice versa. In effect the torque/speed curve of the induction motor is changed to the 'shunt' form for any required operating speed.

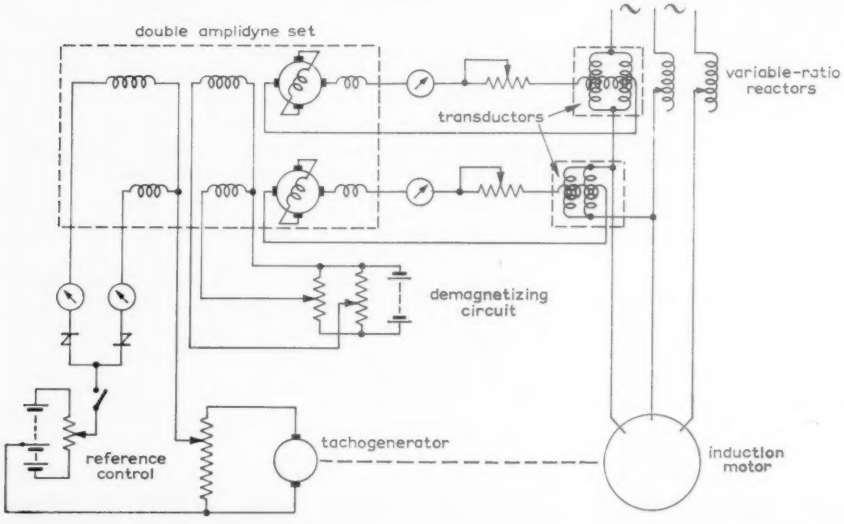
The principle was demonstrated using a negative-feedback circuit. An amplidyne generator was used to control the field current of an alternator which supplied the induction motor.



1 *Torque/speed curves produced by speed stabilizing*

The field current of the amplidyne generator was determined by the difference between a variable reference voltage and the output voltage of a tachogenerator coupled to the induction-motor shaft. A rectifier was connected in series with the amplidyne field winding to prevent the positive feedback which could occur since the output of an alternator is independent of the direction of current flow in its field winding.

Some typical torque/speed curves for a range of constant reference voltages are shown in Fig. 1. The change in slope at low torques is due to residual flux in the alternator field system. This arrangement clearly demonstrates the principles of speed stabilizing and while it has several disadvantages, particularly the inevitable low efficiency at low speeds, it is cheaper in capital cost than a Ward Leonard set.



2 *Speed stabilizing by controlled asymmetry*

Speed stabilizing by controlled asymmetry

An alternative means of speed control involves a difference in the method of stabilizing the speed, the required variation in the torque of the machine being obtained by automatic control of the degree of asymmetry of the stator voltages.

The method was demonstrated using the circuit shown in Fig. 2. The output voltage of a tachogenerator was compared with a reference voltage and the difference used to excite one or other of the amplidynes which supplied the bias to two transductors. Two variable-ratio transformers were inserted to balance the supply voltage when the impedance of transductor A was least. The gain of the circuit was adjusted by means of the resistors in series with the transductor bias windings.

Consider the effect on the torque/speed curves of the induction motor of assigning different combinations of infinite and zero impedance to transductors A and B. The resulting torque/speed curves are (a) a standard 3-phase curve when A is zero and B is infinite, (b) a single-phase curve when A and B are both infinite, and (c) a dynamic braking curve when A is infinite and B is zero. By varying the impedances of A and B it is possible to obtain a series of intermediate torque/speed curves, and by doing this automatically shunt-type characteristics can again be obtained.

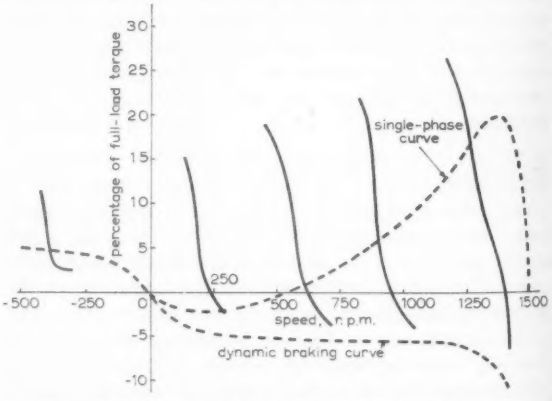
Two suitably designed transductors were not readily available; as a makeshift four single-phase transformers were used. The secondaries of each pair were connected in parallel and carried the current to be controlled while the primaries carried the control current. The magnetomotive force produced by the control current assisted the secondary m.m.f. in one transformer and opposed it in the other.

Unfortunately the rated current of the transductors was less than the full-load current of the induction motor, and the B/H curve for the transductors differed substantially from the ideal. These factors greatly worsened the possible performance of the induction motor, and the results quoted are therefore not truly representative of this method of speed control. However in spite of the highly inefficient improvised equipment the speed-control system worked satisfactorily and showed no tendency to become unstable.

Fig. 3 shows some typical torque/speed curves for constant reference voltage. The maximum output torque was low but the curves cut the speed axis steeply; this allowed excellent speed control for light torques. The slope decreased for high torques and in the braking region owing to the poor performance of the transductors.

Conclusion

The two methods of wide-range speed control outlined above are obviously not beyond improvement; and the systems in



3 *Torque/speed curves for speed stabilizing by controlled asymmetry*

their present form were developed just sufficiently for workable demonstrations to be given. The two amplidynes for the method employing controlled asymmetry could, when properly designed self-exciting transductors are used, be replaced by a small low-power magnetic or electronic amplifier. This would improve the performance, and the system would be inexpensive.

The great disadvantage of the speed control of an induction motor at large slips is its poor efficiency but this can be tolerated for many applications when the induction motor is required to operate at large slips for short periods only. The efficiency at low speed could be improved by applying one of the methods of speed control to a pole-changing motor. It may well prove possible to apply the principles of controlled asymmetry to a polyphase machine run from a single-phase supply.

621.313.333.2:621.316.718.5

Insulation failure

A brief article based on a Graduate and Student Section paper with the above title by J. A. Denham, B.Sc.(Eng.), Graduate. The paper is the Chairman's Address to the North-Eastern Graduate and Student Section and was read on the 10th October 1958 at Newcastle upon Tyne. It was awarded a premium by the Council. The author is with C. A. Parsons and Co. Ltd.

In all their many and varied applications insulating materials can fail. Failure can be brought about by electrical mechanisms, mechanical damage, chemical action or too high an operating temperature; it can happen suddenly or take many years to develop.

Recognizing the cause of an insulation failure and proposing a replacement system or repair are serious problems. Of the several mechanisms of failure only a few can be clearly defined. These are intrinsic breakdown, thermal instability, electrochemical and chemical deterioration, and failure due to internal and external discharges.

The intrinsic electric strength of a material can be obtained only by carefully eliminating all other possible breakdown mechanisms. The material under test must be homogeneous, absolutely pure and completely without flaws. Considerable attention must be paid to the form of the test electrodes.

Thermal instability

The temperature of an insulating material in an electric field rises because of conduction currents or energy losses which generate heat. If thermal equilibrium is not attained and a continuous temperature rise occurs breakdown follows either because of thermal decomposition or through mechanical failure. The thickness of insulation cannot be increased indefinitely because at some stage surface conditions have little effect on the internal temperature. There is thus a maximum voltage independent of thickness above which failure of the insulation occurs. This is known as a thermal voltage and generally is a vital factor only for high-temperature operation or at frequencies above 1 Mc/s.

Electrochemical failure and oxidation

Electrochemical deterioration is brought about by the liberation of ions at electrodes by conduction currents. Ionic conduction always implies the transport of matter. Damage resulting from electrochemical action depends on the current and very much on the nature of the ions transported and their chemical reactions with the remaining insulation. The presence of impurities, in particular moisture which promotes ionization in dissociable material, can increase the rate of deterioration.

Most insulating materials fall into the chemical class of organic compounds and almost without exception are liable to undergo slight changes in chemical constitution which are affected by the presence of oxygen, moisture, chemically active materials and ionized air. The most common form of chemical deterioration is slow oxidation which by introducing acid groups into the polymeric or liquid insulation increases the conductivity and loss factor of the insulation. Oxidation also splits up the polymer chains in plastic insulation and decreases the tensile strength.

1 *Long erosion path on micanite surface*

Erosion by discharges

Discharges can occur in a gas-filled void at quite low electric stress. Initially the surfaces of the void are slowly eroded by ionic bombardment and small pits are formed. In polythene after some hours the discharges concentrate at certain positions forming deep uncarbonized pits which are surrounded by a layer of resin. The mechanism undergoes a change when these pits attain a critical length, and partially carbonized

Table 1. Effect of improved manufacture on a 33kV concentric conductor bar

	Constituents % by volume (average)				Thermal conductivity k (kW/in.²)/(deg C/in.) (insulating tube)		
	mica	varnish	backing material	air	bull	inner	outer
Previous technique	46·3	34·5	6·0	13·1	0·00627 [80°]	0·00304 [75°]	0·00408 [56°]
Improved manufacture	57·0	34·2	7·9	0·9	0·0036 [86°]	0·0063 [81°]	0·0079 [73°]

Figures in brackets after thermal conductivities indicate copper temperature, deg C

sinuous channels of much smaller diameter develop at the ends of the pits. Often this change in mechanism causes complete failure but sometimes excessive carbonization short-circuits the discharges and the activity ends.

Erosion by external discharges occurs in certain conditions at the surfaces of insulation, and failure can result after a considerable time. It has been shown that chemical deterioration of organic insulation exposed to external discharges can take place owing to the absorption of chemically active gases produced by the discharges.

Identifying the cause of failure

The determination of the cause of a particular failure may be impossible if a large current has passed through the fault. Conclusions have to be reached from the available evidence which is always assembled after careful and painstaking examination.

Erosion of insulation by external discharges can generally be readily seen as eroded grooves or holes. Fig. 1 shows a long erosion path on the surface of a piece of micanite. Electrochemical and chemical deterioration can be shown by chemical analysis.

Thermal instability is a most difficult breakdown mechanism to recognize. Examination of the surrounding insulation indicates if it has been overheated but if large fault currents have passed through the failure such an analysis is very difficult. The most useful tool for investigating this type of failure is a collection of comparisons that have been prepared in the laboratory.

Mechanical damage can cause the failure of insulation, for example damage can be caused by the large forces that occur between conductors that have been subjected to short-circuit conditions.

Mechanical properties can deteriorate at high temperature and so thermal endurance is an important property that has gained emphasis with the increase in operating temperatures.

Fig. 2 shows cracking that has taken place in an epoxy-resin casting that has been operated for too long above its accepted operating temperature.

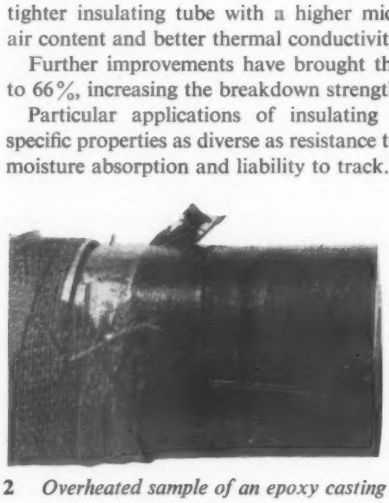
Direct cooling, as with the water-cooled stator, has eased the thermal problem as the heat is removed from the conductor directly by gas or water and not through layers of insulation.

Manufacturing techniques

The study of manufacturing techniques is as important as the choice of the right material. An example of an improvement in the electrical and thermal properties of a high-voltage concentric conductor bar brought about by improved manufacture is shown in Table 1. The new process results in a tighter insulating tube with a higher mica content, smaller air content and better thermal conductivity.

Further improvements have brought the mica content up to 66%, increasing the breakdown strength considerably.

Particular applications of insulating materials demand specific properties as diverse as resistance to abrasion, fungus, moisture absorption and liability to track. Most important is reliability: insulating materials must not fail thermally, mechanically or electrically and yet must be capable of economic operation.



2 *Overheated sample of an epoxy casting resin*

Need for understanding

By understanding breakdown mechanisms engineers can try to control them, examples being the use of inhibitors in capacitor impregnants where the life of the capacitors has been increased 30 times and the covering of stator conductor bars with sleeves coated with colloidal graphite which has stress-relieved the surface and thus eliminated the effects of external discharges on the main insulation.

By understanding the physical basis of materials we can employ them to their best advantage or even improve them. For example the irradiation of polythene has greatly enhanced its mechanical properties.

Improvements in the quality of insulating materials, particularly synthetic varnishes, have markedly increased their working life.

One must not give the impression that insulation constantly fails or gives rise to considerable apprehension. It sometimes leads a hazardous life but it does generally last. Nevertheless insulation failure in service can cause significant delays and inconvenience although the repair of even serious damage is always rapid.

Research continues as there is still much to learn: the E.R.A. and the universities contribute enormously to the theories of breakdown, while industry is busy examining the immense range of new materials. 621.315.61.620.19

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

GEORGE BRADFORD

George Bradford, M.ENG., died in Sheffield on the 8th October 1958 while on leave. His death removed from the Rhodesian scene a well known and well loved figure. He was born in Liverpool on the 7th June 1897 and was educated at Liverpool Collegiate School. After serving with the Royal Engineers in the 1914–18 War he returned to study at Liverpool University where he obtained his degree. He joined Metropolitan-Vickers Electrical Co. as a college apprentice in 1920 and after the completion of the course stayed on in the works to take charge of the heavy-plant testing department.

He went to Rhodesia for the company in 1927, his first job being to erect generating plant in the Mulungushi power station of the Rhodesian Broken Hill Development Co. and rotary-convertor plant in their refinery substation. He then became sales manager for the company in Ndola and later Johannesburg, leaving it in 1937 to join the Anglo American Corporation of South Africa as a consulting mechanical and electrical engineer which post he held until his death, being based at Johannesburg up to the end of 1955 and in Salisbury from that date.

During his long period of office with the Anglo American Corporation he was responsible for the mechanical and electrical engineering side of the vast programmes of expansion in the gold, diamond and base-metal mines of the corporation. In the latter field his work constituted a substantial contribution to the development of Northern Rhodesia and in particular to the large post-war expansion of the Nkana, Nchanga and Broken Hill mines and the establishment of the Bancroft mine and the Rhodesia Congo Border Power Corporation.

He is survived by his widow, two sons and a daughter.

He joined The Institution as a Student in 1920 and was elected an Associate Member in 1925 and a Member in 1946. A. G. V. P.

WILLIAM HERBERT GRINSTED

The death on the 26th September 1959 of William Herbert Grinsted, O.B.E., marked the passing of one of the pioneers of telephone-engineering work in this country.

He was born on the 11th July 1885 and was educated at Horsham Grammar School and the Central Technical College, South Kensington. In 1911 he joined Siemens Brothers and Co., Woolwich, from the National Telephone Co., as head of the telephone-engineering section and soon gained a reputation for his original work on telephone-traffic studies. From 1927 until he retired in 1958 he held the position of chief telephone engineer and later director of engineering for telecommunications and cables. Such a long period in a high technical executive position must be rare.

It is difficult to find suitable words to express the qualities which made him universally respected in the whole telephone industry whose growth he had seen and to which he had contributed so much. He was never a man to seek publicity for himself. He was always kind and understanding towards those who worked for him. He worked actively to further technical education and was a member of various committees which served this end.

Outside his wide business activities he found time to have interests in literature and music. He is survived by his widow.

He joined The Institution as a Student in 1905 and was elected an Associate Member in 1912 and a Member in 1941. He was appointed a Member of the Order of the British Empire in 1946 and an Officer in 1953. He was awarded the Fahie premium in 1920 for a joint paper with E. A. Laidlaw entitled 'The telephone service of large cities with special reference to London' and in 1949 for his paper 'The motor uniselector and the technique of its application in telecommunication' which were published in the *Journal* in 1919 and the *Proceedings* in 1949 respectively. L. S. C.

FRANK OLLERENSHAW HARBER

Frank Ollerenshaw Harber who died on holiday while visiting friends at Pontadog on the 5th August 1959 was born on the 22nd March 1898. He was educated at Acock's Green School and received his technical education part-time at Birmingham Technical School and at Birmingham University while a pupil with Arthur Gibbs and W. H. Bidlake and apprenticed to Bowden Brake Co., Birmingham.

In the 1914–18 War he served as a sub-lieutenant in the Royal Naval Volunteer Reserve and in the Second World War he qualified as a Royal Air Force glider pilot and instructor, devoting his spare time to training squadrons at the North Wales Air Training Corps Gliding School.

In 1920 he became an engineer with Waygood-Otis Ltd. and in 1924 transferred to Metropolitan-Vickers Electrical Co. as a designer and engineer in the e.h.v. switchgear department. He joined R. G. Cunliffe, consulting engineer, in 1928 as chief assistant and in 1931 took an appointment as mains superintendent with Aylesbury Corporation which position he left in 1935 to take up the duties of chief electrical engineer and manager to Portland Urban District Council. In 1940 he became borough electrical engineer and manager to Bangor City Council which position he held at vesting date. Following the nationalization of the electricity supply industry he was appointed district engineer for the Oswestry District of the Merseyside and North Wales Electricity Board.

A member of Oswestry Rotary Club, he travelled with his wife to Russia and countries in Central Europe with a party of Rotarians from the British Isles and the U.S.A. in 1958, and on his return he addressed many organizations about his experiences. He was a member of the North Shropshire Youth Committee, being vice-chairman up to July 1959, and a Freemason. He was particularly interested in painting and the arts, also in gardening and bee-keeping. While at Bangor he worked out a plan for harnessing the tidal power of the Menai Straits with two reservoir arrangements which would provide generating power by the rise and fall of the tides. He made many friends wherever he went. He is survived by his widow.

He joined The Institution as a Student in 1921 and was elected an Associate Member in 1929 and a Member in 1947. W. A. W.

JOHN PURRETT

John Purrett who died on the 19th July 1959 was born at Banwall, Somerset, on the 1st April 1875 of farming ancestry. He was educated locally and at Merchant Venturers Technical College, Bristol. He then became physics master at Rugby School and in 1897 joined Williams and Robinson, Rugby, as a test-room assistant.

Three years later he joined Bryant and Lindley and was responsible for carrying out tests on the various plants which they installed. It was during this time that he became acquainted with the late C. D. Taite under whose management he served from 1907, as deputy engineer and manager with the Lancashire Electric Power Co., until he retired in 1947. During this period he was personally responsible for the commercial and consumer requirements of the company. He was an acknowledged authority on all kinds of mill installation and on textile drives and machinery.

He was a man of a very retiring but likeable disposition having no enemies, few casual acquaintances but many friends. His ability to hand on to those he knew the wealth of knowledge he possessed made him appreciated and respected by all with whom he came in contact. He was for many years chairman of the local Engineers' Bulk Supply Association and his knowledge of the requirements of the industry and his ability to deal with awkward situations made him much liked and admired.

He was never more happy than when at work and had few hobbies, but he was a keen chess player and a master of the game. He spent much of his leisure time in his workshop, modelling and carrying out experiments for improving and designing electrical and mechanical equipment. 'Honest John' as he was known to all his most intimate friends will be greatly missed but his influence on the electricity-supply and textile industries will continue for many years. He is survived by a son and two daughters.

He joined The Institution as an Associate Member in 1901 and was elected a Member in 1912. S. L. D. L.

JOHN WESTMORELAND RECORD

John Westmoreland Record who died on 9th October 1959 was born in London in 1881.

He commenced his business career in a City stockbroker's office but soon realized that this was not his calling and that the field of electrical engineering offered more scope for his creative abilities. His early years were spent with a number of electrical-instrument manufacturers in London and he finally moved to the Manchester area where he joined the Salford Instrument Co.

In 1911 he founded the Record Electrical Co. to manufacture electrical measuring instruments. He designed a range where the scale length was over twice the dial diameter.

He was a man of retiring disposition but nevertheless possessed great determination which he used, like many early pioneers, in perfecting and expanding his range of instruments. His principal hobby was music, especially the playing of his 'cello. He also made and sailed model yachts.

He joined The Institution as an Associate in 1904 and was elected an Associate Member in 1906 and a Member in 1922. His paper written jointly with Dr. W. E. Sumpner entitled 'New alternate-current instruments' was published in the *Journal* in 1908. He was a member of the Technical Committee of the British Electrical and Allied Manufacturers' Association Instrument Section in 1918.

A. R. P.

JOHN WALTER SIMS

John Walter Sims who died on the 29th March 1959 was born on the 29th October 1881. He was educated at Manchester Grammar School and was apprenticed to Laurence, Scott and Co., Norwich, attending Norwich and Birmingham Technical Schools part-time.

In 1909 he became a draughtsman-designer with Veritys Ltd. and commenced teaching machine design at evening classes at Birmingham Municipal Technical School. He joined the City and Guilds Engineering College in 1912 and was employed in the drawing office, being responsible for teaching students all the detailed drawings in electrical-machinery-design courses under the direction of Dr. S. P. Smith. Ultimately he was promoted to lecturer, and in addition to drawing-office work he gave a regular course of lectures on workshop organization and was in charge of the administrative work of the department. He retired in 1946.

He is survived by his widow and three sons.

He joined The Institution as an Associate Member in 1910 and was elected a Member in 1924.

A. R.

SIR DUNCAN WATSON

Sir Duncan Watson, J.P., who died on the 27th September 1959 at his home at Scammell's Corner, near Dorking, was born in 1873 and educated at Hutchinson's Grammar School, Glasgow, the Glasgow and West of Scotland Technical College and King's College, London. He received his engineering training with Mavor and Coulson, Glasgow, and then moved to London where he commenced his electrical engineering business in 1898 and founded the firm of Duncan Watson (Electrical Engineers) Ltd.

He became interested in municipal matters and was elected a councillor of the St. Marylebone Council in 1909, becoming alderman in 1915, mayor in 1919–20 and a Justice of the Peace for the county of London.

From 1912 to 1925 he was chairman of the Electricity Committee and had much to do with the formation and running of the Conference of London Authorities Owning Electrical Undertakings in Greater London, of which he was chairman from 1918 to 1925. Thereafter he became the first chairman of the London and Home Counties Joint Electricity Authority. He had a great deal to do with the 1926 Electricity Bill and was appointed a member of the Central Electricity Board on its formation in 1927, a position which he held continuously until the nationalization of the industry in 1948. He also served as a member of the North of Scotland Hydro-Electric Board from its inception in 1943 until 1948.

During the last 28 years he was a director of the Perak River Hydro-Electric Power Co. and prior to nationalization was a member of the board of the Midland Counties Electric Supply Co. and of the Llanelly and District Electric Supply Co. He was chairman of the Harley-Davidson Motor Co.

His success as a member of the many electricity undertakings to which he was appointed was due to his obvious sincerity and his very lively Scottish sense of humour allied to a forcible yet tactful advocacy.

He was a governor of Regent Street Polytechnic, London, from 1931 to 1953 and being an authority on electricity supply gave most useful advice on the subject of engineering training. He made many donations to The Polytechnic but his most generous donations were to the scholarly funds—the principal one being to the memorial of the late Lord Hailsham.

He is survived by a son and two daughters, his wife having predeceased him in 1946.

He joined The Institution as an Associate in 1897 and was elected an Associate Member in 1899 and a Member in 1907. He was knighted in 1927.

E. R. W.

GEORGE ANDREW PHILIP WEYMOUTH

George Andrew Philip Weymouth who died on the 10th July 1958 at Townsville, Queensland, was born in Victoria in 1867. He obtained his engineering education part-time at Finsbury Technical College, London, while working for Johnson and Phillips and later Siemens Bros. and Co.

In 1895 he returned to Australia and started manufacturing electrical machinery on his own account in Melbourne. In 1901 he founded one of the first electrical companies, G. Weymouth Pty. Ltd., at Richmond, Victoria. After many years of successful business operation he sold his interest in the company and joined the Clyde Engineering Co., Granville, New South Wales. He was appointed a director in 1929, managing director in 1934 and chairman in 1937. He retired in 1941.

The Clyde Engineering Co. is a heavy-engineering company and during the difficult period that he was associated with it important contracts concerned with the development of Broken Hill Pty. Ltd., the construction of locomotives and railway rolling-stock, were undertaken. Changing over from peace-time to full war production for the Australian and United States military forces was also carried out during that period.

He joined The Institution as an Associate in 1893 and was elected an Associate Member in 1900 and a Member in 1911.

J. T. R.

CORRESPONDENCE

SYMBOLS FOR SPACE CO-ORDINATES

MR. Page's Fig. 3a (November 1959 *Journal*, p. 657) is precisely what I am advocating and agrees exactly with Fig 3b; but unfortunately it is not what Mr. Page himself and many others use when analysing, in Cartesian co-ordinates, electromagnetic-wave propagation problems. These authors quite needlessly and arbitrarily orient the co-ordinates so that the power P is in the z direction. The result is a great handicap to teachers in their efforts to present to their students a unified and coherent picture of guided waves whether associated with transmission lines or waveguides.

Moreover the whole point about the use of r for the radius vector in both cylindrical and spherical co-ordinates is that it has the same meaning in both systems and contrary to Mr. Page's argument confusion is thus avoided.

In spite of what Mr. Page says I think it must be conceded that there are at present no universally accepted 'standard' systems of space co-ordinates. My plea is for the adoption of such systems in rectangular, cylindrical and spherical co-ordinates, logically related to one another so as to use as few independent symbols as possible and based on the orientation long accepted in transmission-line practice.

Prof. H. E. M. BARLOW, PH.D., B.SC.(ENG.), MEMBER

10th October 1959 University College London

PAPERS AND MONOGRAPHS
published individually this month

Papers accepted for reading at meetings and monographs are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition reprints of papers read at meetings including the discussions thereon and of papers not read at meetings become available, price 2s., within two months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary of The Institution. For convenience books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the part of the Proceedings in which it will be republished—to apply in due course for a reprint as this is the final and correct version and includes the discussion.

PAPERS

Input impedance of rectifier modulators *Paper* 3187E: *Part B*

PROF. D. G. TUCKER, D.SC.

IT is shown how the input impedance of a rectifier modulator of series, shunt or ring type can be calculated, and a large number of cases are tabulated assuming (1) that the terminating impedances while being as frequency-selective as desired are nevertheless purely resistive at all modulation-product frequencies where they are not zero or infinite and (2) that the rectifiers have a square-wave variation of resistance with time.

In all cases except one (i.e. a ring modulator with constant-resistance load) the input impedance—defined as the ratio of the input voltage to the input current at the applied signal frequency—has the peculiar property of being dependent on the nature and magnitude of the signal source impedance from which it is being measured.

To be read on the 11th January 1960

Rectifier modulators with frequency-selective terminations *Paper* 3051E: *Part B*

D. P. HOWSON, M.SC., *and* PROF. D. G. TUCKER, D.SC.

SOLUTIONS are obtained for the modulation-product currents in series- and shunt-type rectifier modulators by separating out an equation for each possible modulation-product frequency and by assuming (a) square-wave switching of non-reactive rectifiers and (b) signal-path terminating impedances which are a pure but not necessarily constant resistance—or zero or infinite—at each modulation-product frequency involved.

The conditions in which there are no even-order modulation-product currents are determined, and the influence of such currents when they do exist is examined. Experimental results confirm the theory. All the working and conclusions apply exactly to the ring modulator provided that terminations required for odd-order modulation-product frequencies are applied in the output loop and those required for even-order frequencies are applied in the input.

To be read on the 11th January 1960

Gaseous-discharge phenomena in h.v. d.c. cable dielectrics *Paper* 3144S: *Part A*

E. C. ROGERS, M.SC., *and* D. J. SKIPPER, B.SC.(ENG.)

CONSIDERATIONS of the short-time electric strength and of the conductivity/temperature/stress relationships show that both impregnated paper and polythene are likely to be satisfactory dielectrics in h.v. d.c. cables. From a.c. experience however it is known that polythene in particular is very vulnerable to damage caused by discharges in gas-filled cavities, and an assessment of the importance of this mode of deterioration in d.c. conditions is therefore necessary.

Calculations have been made of the repetition rate of discharges in a gas-filled cavity in a dielectric subjected to a d.c. stress since this is clearly a decisive factor determining the rate of deterioration. The repetition rate is a maximum when the surface conductivity of the dielectric is zero. Direct measurements of the repetition rate of discharges are described. The measured rates are consistent with the calculated maximum rates. The effects of ripple voltages and polarity reversals are examined.

From the predicted discharge-repetition rates and from the results of accelerated life-tests on samples containing cavities a rough estimate can be made of the effect of discharges on the probable life of an h.v. d.c. cable dielectric. Polythene was selected as the example for study on account of its known vulnerability to discharge. With this material, discharge damage is unlikely to be a serious problem in d.c. conditions provided that ripple voltages are not excessive and that very frequent reversals of polarity can be avoided.

To be read on the 13th January 1960

Application of power transistors to the operation of gas-discharge lamps from d.c. supplies *Paper* 3192U: *Part A*

I. F. DAVIES, B.SC., *and* D. DUNTHORNE, B.SC.(ENG.)

THE high-frequency (up to 20kc/s) operation of fluorescent tubes is considered. Characteristics of sine-wave and square-wave transistor inverters are discussed, and a preference is expressed for sine waves for lamp operation. Design details and component characteristics for sine-wave lamp inverters are propounded and various types of circuit are referred to.

To be read on the 14th January 1960

Design of housing-estate distribution systems using a digital computer *Paper* 3131S: *Part A*

R. L. GRIMSDALE, M.SC., PH.D., *and* P. H. SINCLARE, M.SC.

AN automatic method for designing housing-estate distribution systems is described which offers a practical and economical alternative to present design techniques. Substation positions and feeding arrangements are calculated instead of being determined intuitively, resulting in better lay-outs and closer approaches to given engineering limits. The method was applied to four housing estates and achieved savings ranging from 6 to 15% of the m.v. mains expenditure required by the previous manual designs. Apart from capital savings uniform standards of design are obtained and designers are relieved of much tedious work.

The automatic method can facilitate management decisions by supplying cost figures for variations in design. For example alternative substation sites may be tested when optimum sites are difficult to secure, the cost of increase in assumed a.d.m.d. can be determined and variations in the number of standard cable sizes can be investigated.

Special features of the automatic method are the division of irregular estate areas and a road-selection procedure which establishes the shortest route between two points.

Due for reading in the second half of the session

Papers and monographs (continued)

Logical design of electrical networks using linear-programming methods *Paper* 3138s: *Part A*

U. G. W. KNIGHT, B.SC.(ENG.)

THE author reports the results of an investigation into the application of linear-programming methods to electrical power-system network planning.

Starting with the geographical positions of the substations which it is required to interconnect a set of formulae can be derived which are solvable by linear-programming techniques to obtain an outline minimum-cost network design. Any security of supply conditions thought necessary can be incorporated into the equations. The formulae for two other possible network-design criteria, minimum circuit length and minimum power-resistance product, are established and discussed.

It is considered that the minimum-cost criterion will have the widest application, and the solution of the linear programmes posed by the use of this standard calls for the employment of a large digital computer. Suggestions are made for increasing the size of problem solvable on a given computer. An extension of the method to deal with multivoltage network planning is briefly examined and the possibility of further mechanization of the design process is mentioned.

Due for reading in the second half of the session

Water-turbine-driven induction generators *Paper* 3140s: *Part A*

C. L. C. ALLAN, B.A.

THE author outlines the main difference between motor and generator operation and considers the excitation of generators, in particular that provided by system capacitance. Results are given of tests on machines to ascertain the practical effects of uncontrolled excitation and switch-in currents. Some advantages arise from absorption of reactive current produced by long transmission lines and reduction in voltage drop on lines delivering power.

The equipment necessary for control, protection, starting and synchronizing is described. Technical aspects of drying out windings and checking phase rotation are studied. Three typical schemes are discussed and existing and planned installations are listed. An appendix deals in more detail with the theoretical values of the equivalent circuit, torque and power factor as well as with circle diagrams.

Due for reading in the second half of the session

Impulse strength of impregnated-paper dielectrics as used in h.v. cables *Paper* 3143s: *Part A*

B. F. SALVAGE, B.SC.(ENG.), PH.D., *and* J. A. M. GIBBONS, B.SC.

AN investigation into the impulse strengths of model cables and cable-impregnating oils and compounds is described. In particular the effects of the density, air permeability and thickness of the paper and the dielectric thickness and temperature of the impregnant have been studied.

Special papers possessing a combination of properties designed to give a high impulse strength have been incorporated in an experimental oil-filled cable and the improvements obtained closely approach those indicated by measurements on model cables.

An impulse-breakdown mechanism in a fully-impregnated-paper cable dielectric is suggested whereby the impulse strength, although it may be varied by changing the properties of the paper, is shown to be primarily dependent on the impulse strength of the impregnant.

Due for reading in the second half of the session

MONOGRAPHS

Some tests for the number of positive zeros and for the numbers of real and complex zeros of a real polynomial *Monograph* 350M

O. P. D. CUTTERIDGE, M.SC.(ENG.), PH.D.

THE numbers of positive, real and complex zeros of a polynomial with real coefficients are related to the number of changes in sign along one or two sequences of determinants whose elements consist of the coefficients of the given polynomial and of its derivative. This in turn is related to the number of negative signs occurring in a certain continued fraction.

Some numerical examples illustrate the application of both methods.

Electronic telephone exchanges

AN experimental electronic telephone exchange is undergoing exhaustive tests at the Post Office Research Station at Dollis Hill, London. When these tests have been completed equipment for about 1000 lines will probably be installed within two years for the public exchange at Highgate Wood, North London.

The introduction of electronics into telephone-exchange design is expected ultimately to reduce initial cost, result in smaller and less equipment which will need reduced space in buildings, and give greater reliability because of the virtual absence of moving parts.

Although this experimental model is not built as a public exchange it does provide facilities for telephone calls within the research station and into the London public-telephone system. It will be used to prove the principles involved in designing electronic-exchange systems.

As early as 1955 it was realized that a considerable research and development effort would be required to apply electronic techniques to telephone switching and provide an effective answer within a reasonable time.

So in 1956 the five principal British manufacturers of telephone-exchange switching systems and the British Post Office decided to set up a Joint Electronic Research Committee.

In pooling their research and development resources the six organizations making up the committee decided to undertake long-term studies on the best system to be employed and also to obtain practical experience in designing and operating exchanges using electronic equipment.

The experimental exchange at Dollis Hill will help in furthering both objects. Each member organization of the J.E.R.C. has taken responsibility for detailed study of a portion of the system, and the individual parts developed are now working together in the experimental exchange.

When the Dollis Hill installation has been fully proved the next stage will be to manufacture the Highgate Wood exchange equipment. When this is completed it is intended to carry out extensive evaluation trials of the public use of the electronic exchange. The electronic exchange will work with and into electro-mechanical exchanges and will provide subscriber dialling of trunk calls and other new services as they are introduced into the London area.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned except where otherwise stated

BRITISH BROADCASTING CORPORATION

Engineering Monograph 26 **Transistor amplifiers for sound broadcasting** by S. D. Berry. 5s.

THE booklet deals with the application of transistors to the high-performance a.f. amplifiers used in sound broadcasting. Five design examples are discussed and the operating conditions of d.c. feedback pairs and of 'super-alpha' pairs are analysed.

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report CL/T1 **Summary of proceedings at international symposium on electricity in the tropics. 1—Climatic conditions and equipment** by M. E. Thompson. 30s. (postage 9d.)

AN international symposium on electricity in the tropics was held in Paris on the 28th–30th May 1956. This is a résumé of the first session comprising summaries of the 12 papers and shortened accounts of the general report and the discussion.

Report F/T194 **Heating of cables: transient temperature rise due to a line source in a semi-infinite medium with a radiation boundary condition** by H. Goldenberg. 7s. 6d. (postage 6d.)

THE author provides a solution to the basic problem involved in the calculation of underground-cable ratings for intermittent loads and specifies the deviation between his solution and that subject to an isothermal boundary condition at the interface. Neher's formula for the steady-state temperature is obtained as an approximation, and an example shows the ratio of transient to steady-state temperature rise at the upper surface of a cable laid direct in the ground in each of the two assumed boundary conditions.

Report L/T357 **The impulse breakdown of uniform-field gaps in air. Interim report** by R. Galloway. 12s. 6d. (postage 8d.)

IN the method described for finding the relation between overvoltage and formative time-lags to breakdown in a uniform-field gap in air at atmospheric pressure the voltage is applied to the electrodes as an impulse wave approximating to a unit function. The results obtained for gaps up to 4cm are given, the overvoltages used ranging from about 3% down to zero.

Report L/T381 **Insulation for small transformers. A guide to design and testing** by J. H. Mason and C. G. Garton. 37s. 6d. (postage 8d.)

THE data include factors affecting the electric strength and life of insulation in service, variation of discharge-inception stress with thickness and permittivity of the material, mechanisms of breakdown by discharges in 'solid' and in oil-impregnated paper insulation, etc. Tables are given of the electrical, thermal and mechanical properties of wire coverings, paper and fabric sheet insulation and laminates.

Report O/T20 **The protection of 11kV and 33kV bushings from damage by arcs in still air and in a wind** by A. E. Guile. 12s. (postage 6d.)

THE report describes the second stage in an experimental investigation to determine the effectiveness of arcing devices in protecting high-voltage insulators and bushing shields from damage in still air and in wind. The first stage was described in Report O/T19 (December 1958 *Journal*, p. 676).

Tests on an 11kV bushing fitted with a single pair of arcing horns have shown that fracture of the porcelain can occur in various conditions but can be avoided by fitting deflector rings and a second pair of horns in parallel with the first.

Report L/T388 **The I.E.C. tracking test. Design of an automatic tracking comparator** by N. Parkman. 7s. 6d. (postage 6d.)

DETAILS of the new international test for tracking are discussed and an automatic apparatus suitable for use in industry is described.

Report O/T17a **The prevention of internal decay in creosoted Baltic redwood poles.** 6s. (postage 5d.)

PHOTOGRAPHS illustrate the results of correct and incorrect practice in creosoting wood poles. The report emphasizes the need for careful selection, seasoning and creosoting.

BRITISH STANDARDS INSTITUTION

B.S. 530: 1948 **Graphical symbols for telecommunications.** Suppl. no. 6. Services' references and additional symbols. 3s.

THE supplement does not constitute part of the Standard proper but relates entirely to the special requirements of the Services. It gives certain symbols additional to those of the Standard and its first five supplements and indicates Services' preferences concerning alternative symbols and deviations from B.S. 530 which the Services find necessary.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

12th survey of electric power equipment Paris, 1959. n.p.

IN two parts the report covers the results of two O.E.E.C. studies, the first on plant development in the electricity supply industry and the second on heavy equipment for power stations. These show the situation on the 1st January 1959 and indicate probable trends up to 1962.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Atom 1959 H.M.S.O., London, 1959. 2s. (postage 4d.)*

THE booklet is an illustrated summary of the authority's annual report for 1958–59 (see October 1959 *Journal*, p. 601).

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Annual bulletin of electric energy statistics for Europe—Vol. 4 Geneva, 1959. 3s. 6d.†

FINAL data are given for the years 1954–1957 and provisional data for 1958. These have been supplied directly by governments to the E.C.E. secretariat.

WIRELESS WORLD

Microwave data tables by A. E. Booth. London, Iliffe and Sons, 1959. 27s. 6d. (postage 1s. 2d.)

ACCURATELY computed tables are given for certain recurring basic information in waveguide and similar transmission-line work including frequency, guide and free-space wavelengths, standing-wave ratio, the decibel, etc.

* Obtainable from H.M.S.O., P.O. Box 569, London S.E.1
† Obtainable from the Sales Section, European Office of the United Nations, Geneva, Switzerland

Technical publications (continued)

BRITISH TRANSPORT COMMISSION

Re-appraisal of the plan for the modernisation and re-equipment of British Railways (Cmd. 813) H.M.S.O., London, 1959. 3s.

THE plan for the modernization of British Railways published four years ago is reviewed in the light of economic and technical developments which have since occurred and future trends. The course of the plan particularly in the next five years is set out. See p. 623, November 1959 *Journal*.

LIGHT RAILWAY TRANSPORT LEAGUE

The future and rapid transit by B. J. Prigmore. Light Railway Transport League, 1959. 2s. 4d. post-free*

THE author surveys accepted forms of urban and suburban transport in Europe and the United States and shows the advantages to be derived from a railed reserved-track electric transport system for rapid transit particularly in peak hours, with reference to schemes already planned or in use in the United Kingdom.

* Obtainable from 21 Endymion Road, London N.4

SOME RECENT BOOKS

F. A. BENSON and D. HARRISON

ELECTRIC-CIRCUIT THEORY

EDWARD ARNOLD. 1959. 371 PP. 30S.

THIS work deals with quite a wide field of introductory circuit calculation. In a manner slightly breathless and occasionally somewhat loosely-linked it covers the familiar ground considered by the authors as appropriate to the first two post-intermediate years of engineering courses in a university. There are worked examples on nearly every page, collections of problems with answers after every chapter, and clear diagrams throughout. Hints on problem-attack are freely sprinkled. The result has a certain workaday utility.

The text has been compiled (as so many are) from lecture notes. It looks just like that. The surprising thing is that it emanates not from a technical college but from the electrical engineering department of a university.

The title is misleading for there is little theory in the mass of technique, and what there is spreads pretty thinly. No attempt is made to explain the basis or validity of the circuit concept or to treat it comprehensively or formally. Statements are often bare and colloquial, sometimes wrong ('magnetic flux is measured in units which are really the product of volt-seconds and square metres but are called webers'). The fundamental ideas are sometimes suspect ('Kirchhoff's second law can easily be deduced from Ohm's law'). Even Kirchhoff's laws do not get beyond a statement for a particular case.

Under a title such as 'Circuit calculations' the book would make a good examination cram.

E. C. BERKELEY

SYMBOLIC LOGIC AND INTELLIGENT MACHINES

NEW YORK: REINHOLD. LONDON: CHAPMAN AND HALL. 1959. 203 PP. £2 12S.

IS it conceivable, the author asks, that arguments of all kinds will in the future be settled not by human beings arguing about them but by automatic computers calculating the answers? Coupled with a reference to Molière's 'Bourgeois gentilhomme' who suddenly discovered that he had been speaking prose all his life, this indicates the author's viewpoint. We all use logic to some extent; there are rules for translation from verbal logic to symbolic logic and from that to Boolean algebra; and computing machines can be designed in terms of Boolean algebra; therefore there is no reason why the man in the street should not understand both symbolic logic and the programming of digital computers.

There are unfortunately some misprints which are obvious to the knowledgeable reader but possibly confusing to the beginner; and the electrical engineer will surely shudder at the sketch of an electrical relay on p. 64.

The book contains many simple examples of logical situations and their representation in symbolic logic, Boolean algebra and relay combinations. It is useful for 'reading around' the subject but most engineers will prefer a more explicit approach to the ideas in the first instance. The bibliography ranges from Russell and Whitehead's 'Principia mathematica' to Berkeley's 'Brainiacs—simple electric brain machines and how to make them'. There is a good index.

H. BUCKINGHAM and E. M. PRICE

ELECTRO-TECHNOLOGY FOR NATIONAL CERTIFICATE COURSES—VOL. 3

ENGLISH UNIVERSITIES PRESS. 1959. 361 PP. 16S.

THIS is the concluding volume of three textbooks which together cover the syllabus of the Ordinary National Certificate, each volume dealing with approximately one year of the course. The topics considered comprise d.c. machines including their windings; electric and magnetic fields; single-phase and polyphase circuits; transformers; rotating fields and a.c. motors; bridge measurements; rectifiers; electronic principles: economic considerations; and complex waves.

The authors have succeeded in dealing with this wide range of subjects in a very satisfactory way by keeping mainly to essential principles and avoiding an excess of descriptive detail. Numerical examples are liberally used to illustrate the text, and each chapter is provided with numerous exercises (with answers) for the student to work out for himself. A further particularly commendable feature is the inclusion at appropriate places of suggested laboratory experiments.

The book is clearly the work of experienced teachers and can be recommended to all concerned with National Certificate and similar courses whether as teachers or as students.

G. E. CONDOYANNIS

SCIENTIFIC RUSSIAN

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 225 PP. 28S.

PRAISEWORTHY in conception and on the whole well executed this book is addressed to the scientist who wishes to acquire quickly through practice on actual texts a reading knowledge

of modern scientific Russian. As it is essentially a manual to facilitate dictionary translation its emphasis is on the grammatical structure of the language; the orthography and phonology are treated only briefly, with strict relevance to the analytical spirit of the text.

Seventeen quick-reference tables (covering *inter alia* vowel mutations, irregular-noun declensions and number declensions) and four special-word lists (e.g. verb prefixes) take commendable advantage of the fact that Russian lends itself to tabular presentation. Useful hints are given on prefixes and on word-building. Each grammatical point is illustrated and many sentences are analysed word for word. In addition to graded exercises for translation, passages (not graded) are given in physics, chemistry and allied disciplines, drawn mainly from established scientific publications.

The work is for its size exemplary in its thoroughness, clarity and simplicity. Nevertheless it is not entirely suitable for an absolute beginner who may easily be discouraged by the strictly utilitarian and clinical approach.

H. A. HAUS and R. B. ADLER

CIRCUIT THEORY OF LINEAR NOISY NETWORKS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 79 PP. 36S.

THE noise performance of an amplifier depends on the noise factor and gain of each stage taken singly and on the manner in which they are combined. The authors of this monograph have tackled the general problem of optimizing the performance of an arbitrary combination. They take as the cardinal property of a noisy network its 'characteristic-noise matrix' which is compounded from the impedance and noise/e.m.f. matrices and whose elements have the dimensions of power.

In a variety of transformations the eigenvalues (or latent roots) of this matrix are either invariant or are preserved as bounds; they have a physical significance closely related to the 'noise measure' (which for a high-gain stage reduces to the more familiar noise factor) so that their behaviour is a guide to the noise performance attainable in various circuits. It is shown for example that the best noise measure attainable equals the noise measure of the best stage and that if each stage is stable with arbitrary passive terminations the optimum may be attained by mismatching.

This work should be of interest to anyone engaged in research on low-noise devices. The reader should be fairly familiar with matrix algebra as applied to network theory.

B. E. NOLTINGK

THE HUMAN ELEMENT IN RESEARCH MANAGEMENT

ELSEVIER. 1959. 91 PP. 9S. 6D.

THIS is an excellent little volume; in other words the reviewer agrees completely with almost all the author's opinions!

It opens with a chapter on Scientists themselves which emphasizes that staffing a laboratory—'filling it with the right people in the right places'—is the supreme problem in organizing research and that a man should be 'considered as a man, not as a cipher to fill a gap on a paper chart'.

Chapters follow on the Anatomy and on the Physiology of a laboratory—'it is quite impossible to get costs to better than, say, 20%, so that it is a waste of time to insist on greater precision in individual returns'; 'It is an expensive business to engage outside photographers, it is generally a more expensive business to allow amateurs to try their hands as occasion arises'; 'There is a continual danger in scientific establishments of over-emphasizing the administrative side'.

The remainder discusses Seniors, Juniors, Strategy, Output and Ethics—'a scientific training is a necessary qualification for a research director. . . . His own people must know him to be honest and open, though the higher circles of technical and industrial politics in which he moves will almost certainly turn him, while there, into a political schemer.'

Most working scientists would support the author's views, and anyone responsible for the administration or management of research should find the book of interest and value.

L. G. SMITH (*Editor*)

RECENT ADVANCES IN ATMOSPHERIC ELECTRICITY

LONDON: PERGAMON PRESS. 1958. 631 PP. £6

THIS book contains the papers and discussions at the second conference on atmospheric electricity held at Portsmouth, New Hampshire, in May 1958. The first conference held four years earlier reflected the interest in the study of atmospheric electricity stimulated by the Second World War, and this volume is further proof of the rapid advances being made. The subject is divided into three roughly equal sections: fair-weather electricity, thunderstorm electricity, and the lightning discharge.

The treatment is predominantly descriptive and in only one or two papers is there any use of mathematical argument. On the other hand there is a wealth of experimental results and the text is exceptionally well illustrated by diagrams, graphs and some excellent photographs of cloud formations and lightning discharges.

The proceedings will be of special use to those who wish to keep in touch with the research going on in many countries but it will be of interest to all who want to get a general idea of the scope of this important matter. The approach is that of the physicist, so that supply engineers must not expect to find any specific mention for instance of problems of power-line protection though the section on thunderstorm electricity and in particular the paper on equipment for forecasting lightning danger may well be of value to them.

The radio engineer will find a more direct reference to his work in the last section on the lightning discharge which ends with a paper on 'Some characteristics of v.l.f. propagation using atmospheric waveforms' and one on 'The nature of lightning discharges which initiate whistlers'. His interest in atmospherics as a source of interference on the medium- and low-frequency bands and in the effect of precipitation static on reception at higher frequencies will make the other sections also of use to him. He will doubtless be glad to see modern

methods of atmospheric research making so much use of electronics, e.g. in radio-sonde equipment and the employment of radar techniques.

The editor and the publishers have done their work well in achieving a uniform and high quality of production. The price is high but not unduly so for a conference record which will probably be purchased mainly as a reference work for research libraries.

S. AUSTIN STIGANT

THE ELEMENTS OF DETERMINANTS, MATRICES AND TENSORS FOR ENGINEERS

MACDONALD. 1959. 433 PP. £3

THIS volume is in three main parts dealing in an elementary manner with the three interrelated subjects.

In the first part the basic properties of determinants are introduced and illustrated by fully worked examples. Methods useful for the simplification of determinants are discussed including pivotal condensation and the reduction of a determinant to its main diagonal elements while the utility of determinants for the solution of equations is made clear.

In part 2 the properties of matrices useful for the same purpose are treated in detail. The processes of addition, subtraction and multiplication of matrices lead on to matrix equations followed by many worked examples concerned with the partitioning, diagonalization and inversion of matrices to simplify matrix products.

The third part to which the first two parts form a necessary introduction although they are complete in themselves deals fully from first principles with the application of tensors to electrical-network problems. Reference frames and axes and covariant, contravariant and mixed tensors are defined while the solution of tensor equations is clarified by examples showing all the steps in the manipulation of the tensor matrices involved.

The whole book will be of value to advanced students taking National Diploma or Diploma in Technology courses and also to the qualified engineer who desires to study or make reference to the techniques developed.

M. TAUBE and H. WOOSTER (*Editors*)

INFORMATION STORAGE AND RETRIEVAL

COLUMBIA: UNIVERSITY PRESS. LONDON: OXFORD UNIVERSITY PRESS. 1958. 228 PP. £2 8s.

THE U.S. Air Force Office of Scientific Research set up a directorate of research communication, and this book is the full report (papers and discussion) of a symposium which the latter organized to discuss the problem of extracting from library shelves all information on a specific topic demanded by a user.

The first section is in effect a glossary while the papers which follow give a review of the physical devices at present available (punched cards, magnetic tape, etc.) and of the analytical theory of methods of classification and of retrieval. Those interested in developing the subject will find it an interesting survey but there are no ready-made solutions of the librarian's problem.

Elections and transfers

The following elections and transfers approved by the Council are effective from the 5th November 1959

ELECTIONS *Graduates*

ABDULLAH, Mohammad, M.SC.TECH., B.SC.(ENG.)
ALEKSANDER, Igor, B.SC.(ENG.)
ARNOLD, John Spencer
BARBOSA, Sergio Agenor Bebianno
BERNALES, Mario
BONTOFT, Frederick John
BOWDEN, Thomas Martin
BURT, Dennis William
BUTCHER, Ian Robert, B.E.
CONWAY, Terence John
CROMPTON, Leslie
CRONIN, Thomas Francis, B.SC.(ENG.)
DRAKOS, Themistocles
EKEOCHA, Samuel Lemeke
FARRUGIA, Carmel, B.SC.(ENG.)
FIENNES, Jeremy Twistleton Wykeham, B.A.
GIBSON, Gordon Burgess
GRANT, John Albert
HAILSTONE, Eric John
HALE, Maurice
HAMBLETT, Hedley Roger, B.SC.TECH.
HUDSON, Christopher, B.SC.(ENG.)
JAMES, Eric Cecil
JENKINS, Thomas John
JONES, John Francis
JONES, Peter Colin, B.SC.
JULIAN, Michael, B.SC.(ENG.)
KETTLE, James Dudley Norman, B.A.
LEWIS, Raymond Brian
McCARTNEY, Thomas
MACE, David Leslie
MILLINGTON, Robert
MOORE, Robert John, B.E.
MORETON, Peter Lewis, B.SC.TECH.
PEARCE, Alan Edward
PEARSON, Joseph Wardle
PRICE, Vernon Kinglsey, B.SC.
RICHARDSON, Charles Raymond William, B.SC.
ROGERS, Frank
SNAITH, Edwin Roland
STEELE, Raymond, B.SC.
TERRY, Raymond Russell
WARD, Kenneth Lister
WATSON, Ian Alexander, B.SC.
WITRICK, James Charles
WOODWARD, Patrick George, B.SC.

Students

ABBEY, Peter John, B.SC.
ALDRIDGE, Rosalind Lily
ATKINSON, Peter
BAGGETT, John Edgar
BEDSON, Leslie Stuart
BENNIE, William Lyon
BENTHIN, Louis
BLACKWOOD, Thomas Hamilton
BLAND, Randall Kenneth
BOXALL, James Hewlett, B.SC.
BRAIN, Thomas Arthur John, B.SC.
BROADBENT, Peter Reginald, B.SC.
BROOM, Colin Edward
BROUGHTON, James
BROWN, Robert Hulme, B.SC.
BUCK, Raymond George
CARTER, Michael Anthony
DOBSON, Michael William
GOEL, Om Prakash
GRANT, John Victor
GREEN, Norman
GREENBERG, Brian Melvin, B.SC.
GRIMSHAW, Ernest
GRINDELL, Derek William
HODNETT, John Edward
HOLE, Godfrey William Reynolds
JACKMAN, David Radclyffe
KETTLE, David Maxwell
LOVETT, Ronald
NANUA, Amarjit Singh
ODIGWE, Hyacinth Nwafor
PENDLEBURY, Joseph
POTTER, Eric Frederick
PRICE, John David Lewis
PRINN, Douglas George
PURKIS, David John
REDDING, David Sheldon
RIGDEN, David Claude
ROBERTS, Christopher John Udal
SCOTT, Claude Frederick, B.SC.
SHELDON, Neville Thomas
SIDAMPARAPPILLAI, Nagalingamudaly
SIMS, Brian John, B.SC.
SULE, Moshood Ayodele
TATE, Alan
TESSON, Adrian Richard
THIRLWELL, James Edward
TIGWELL, Peter John
WATTS, David
WELAGEDERA, Daiyanwela Nawaratne Yapa Mudiyanse Raiahajilage Ukku Banda
WHITAKER, John, B.SC.
WILSON, John Law
WOOLLEY, Peter Maxwell

TRANSFERS *Student to Graduate*

BARROWCLIFFE, John Kenneth, B.SC.
BOOTH, John Trevor, B.SC.TECH.
BRACHER, Peter Charles, B.SC.
BUTTERWORTH, John Stuart, B.ENG.
CARMICHAEL, Ian Francis
COX, Graham Goodridge, B.SC.
CROOKS, William Ralph, B.SC.
CROSS, William Thomson, A.H.-W.C.
DAWSON, John, B.SC.
DUDHIA, Champaklal Laxmanbhai, B.E.
FARRINGTON, Derek, B.SC.TECH.
GLEW, Charles Neville, B.SC.
HEATH, Ivan Peter, B.SC.
HENSTOCK, Maurice Graham, B.SC.(ENG.)
HODGSON, David, B.SC.
HUMPHREYS, Geoffrey Edward
JOHNSTON, David Lawrence, B.SC.
KECHARANANTA, Pranote, B.SC.
KERSH, Claude, B.SC.
LALL, Roshan, B.SC.(ENG.)
LITTLE, James Joseph
MALCOLM, James Duncan, B.A.
MALIK, Omar, B.A.
MORRIS, Clive John
NEWTON, Donald Joseph
NUTTALL, Lawrence Sutcliffe, B.A.
OPOKU, Nicholas Kobina, B.SC.(ENG.)
PALEY, Derek Brian, B.SC.(ENG.)
PARKES, John Francis Anthony, B.A.
PARTRIDGE, Simon Godfrey, B.A.
PEARCE, Raymond Albert
RYLEY, Derek Vernon, B.SC.(ENG.)
SHEA, Michael John, B.SC.(ENG.)
SHELDON, John Graham, B.SC.(ENG.)
SMITH, Ian Dalgleish Stirling, B.SC.(ENG.)
SONNTAG, Charles Forbes
STEPHENS, Jeremy Hewitt, B.SC.(ENG.)
STYAN, Peter Ormonde, B.SC.(ENG.)
TOPLISS, Richard John, B.SC.TECH.
VERMA, Rabindra Nath, B.SC.
WAFER, Ronald Vincent
WATTS, Donald
WILL, Alexander James, B.SC.
WILLIAMS, Kevan, B.SC.TECH.

*Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

ARDENNE, M. Von 53(083)

Tabellen der Elektronenphysik, Ionenphysik und Ubermikroskopie—Band 1 (Tables of electronic and ionic physics and electron microscopy—Vol. 1)

Berlin: VEB Deutscher Verlag der Wissenschaften, 1956. pp. xvi, 614. 27 × 19·5cm. n.p.

Tabellen der Elektronenphysik, Ionenphysik und Ubermikroskopie—Band 2 (Tables of electronic and ionic physics and electron microscopy—Vol. 2)

Berlin: VEB Deutscher Verlag der Wissenschaften, 1956. pp. xii, 751. 27 × 19·5cm. n.p.

BENSON, F. A., and HARRISON, D. 538.551

Electric-circuit theory*

London: Edward Arnold, 1959. pp. viii, 371. 22 × 14cm. 30s.

Based on lectures for undergraduate students this book covers both light- and heavy-current applications of electric-circuit theory and includes a large number of worked examples a nd problems. It is reviewed on p. 730.

BORCHERT, R., and JUBITZ, W. 621.369

Infrarottechnik (Infra-red technique). **3rd edition**

Berlin: VEB Verlag Technik, 1958. pp. 231. 21 × 15cm. n.p.

Deals briefly with the fundamental principles of the generation of infra-red radiation and its effect on irradiated bodies and discusses applications.

CHESTNUT, H., and MAYER, R. W. 621–52

Servomechanisms and regulating system design—Vol. 1. 2nd edition*

New York: John Wiley. London: Chapman and Hall, 1959. pp. xvii, 680. 23·5 × 15cm. £4 14s.

This is a considerable expansion of the first edition. Introductory chapters deal with differential equations, circuit theory and system stability. The principles of various feedback control systems are described.

HARTMANN, W., and BERNHARD, F. 621.383

Fotovervielfacher und ihre Anwendung in der Kernphysik (Photoelectric multipliers and their application in nuclear physics)

Berlin: Akademie-Verlag, 1957. pp. viii, 188. 24·5 × 17·5cm. n.p.

A survey of the basic principles of operation of the photoelectric multiplier and their bearing on its use as a scintillation counter for measuring elementary particles.

HAUS, H. A., and ADLER, R. B. 621.395.645

Circuit theory of linear noisy networks*

New York: John Wiley. London: Chapman and Hall, 1959. pp. xii, 79. 23 × 15cm. 36s.

A study of the extent to which the amplifier influences signal/noise ratio over a narrow band (essentially at one frequency) in the systems of which it is a part. This book is reviewed on p. 731.

HERFORTH, L., and WINTER, H. M. 534.321.9

Ultraschall: Grundlagen und Anwendungen in Physik, Technik, Industrie, Biologie und Medizin (Ultrasonics: fundamental principles and applications in physics, engineering, biology and medicine)

Leipzig: Teubner Verlagsgesellschaft, 1958. pp. vii, 235. 19 × 14cm. n.p.

JOFFÉ, A. F. 621.315.59

Physik der Halbleiter (Physics of semiconductors)

Berlin: Akademie-Verlag, 1958. pp. x, 400. 24 × 17cm. n.p.

A comprehensive and up-to-date theoretical treatment of the subject.

KILINSKI, E. Von 551.594

Lehrbuch der Luftelekrizität (Textbook of atmospheric electricity)

Leipzig: Akademische Verlagsgesellschaft, Geest and Portig K–G, 1958. pp. vii, 141. 23·5 × 16cm. n.p.

Based on a series of lectures on meteorology and geophysics.

LANGBEIN, R., and WERKMEISTER, G. 621.317.7

Elektrische Messgeräte (Electrical measuring apparatus). **3rd edition**

Leipzig: Akademische Verlagsgesellschaft, Geest and Portig K–G 1959. pp. xii, 251. 21 × 15cm. n.p.

A new edition of a concise work which deals mainly with the accuracy of electrical measuring instruments.

LEWIS, D. T. 539

Ultimate particles of matter; nuclear science simplified*

London: Chantry, 1959. pp. 113. 22 × 14·5cm. 15s.

An attempt to explain to the layman the more complex modern theories of chemistry and physics and in particular nuclear science. The author has used analogy and a sense of humour to keep the reader interested.

LÖSCHE, A. 539

Kerninduktion (Nuclear induction)

Berlin: VEB Deutscher Verlag der Wissenschaften, 1957. pp. xv, 605. 21 × 15cm. n.p.

A discussion of the physical principles of nuclear magnetic resonance and its application to the measurement of magnetic fields and the study of the structure of solids and molecules.

MULLARD LIMITED 621.395.645

Circuits for audio amplifiers

London: Mullard, 1959. pp. vi, 136. 25 × 20cm. 8s. 6d.

Deals with circuits for audio power amplifiers and pre-amplifiers including those for stereophonic reproduction.

MURPHY, G. J. 621–52

Control engineering*

New York: Van Nostrand, 1959. pp. xii, 385. 23·5 × 15·5cm. £2 16s.

Automatic feedback control and related topics are treated carefully at a level which assumes a knowledge of differential equations, electric-circuit theory and mechanics. The Laplace transformation is introduced early in the book and used extensively. Reviewed in November 1959 *Journal*, p. 664.

PRESSMAN, A. I. 621.314.7

Design of transistorized circuits for digital computers*

New York: Rider. London: Chapman and Hall, 1959. pp. viii, 316. 15·5 × 23·5cm. £4

Discusses detailed design calculations for the various types of circuit-element for digital computers in which transistors are used instead of vacuum tubes. Reviewed in October 1959 *Journal*, p. 605.

Library accessions (continued)

REFRIGERATION PRESS LIMITED 621.56

Refrigeration manuals. Vol. 1—Refrigeration educational course

London: *Modern Refrigeration*, 1959. pp. 118. 19 × 12·5cm. 15s.

This is the first of a series of small manuals on refrigeration. It does not aim at education to any particular level and is an elementary introduction to the subject explaining simply the principles of the various methods.

Refrigeration manuals. Vol. 2—Common-sense talks on commercial refrigeration

London: *Modern Refrigeration*, 1959. pp. 152. 19 × 12·5cm. 15s.

This is a simple general explanation of the principles of refrigeration under such heads as compressors, evaporators, condensers, heat-exchangers, moisture and its removal, brine, and ice-making.

RODGERS, T. M. 621.357.7

Handbook of practical electroplating*

New York: Macmillan, 1959. pp. xv, 333. 19 × 13cm. £2 19s. 6d.

General practical information on electroplating arranged in dictionary order.

RUMPF, K. H. 621.396.6

Bauelemente der Elektronik (Electronic components)

Berlin: VEB Verlag Technik, 1959. pp. 292. 21 × 15cm. n.p.

An elementary practical work on resistors, capacitors, electronic valves, transistors and other components.

RYDER, G. H. 531.8

Theory of machines through worked examples. 3rd edition*

Cleaver-Hume, 1959. pp. viii, 280. 22 × 14cm. 21s.

Over 300 graded questions are given of which about half are worked, the remainder being grouped with each chapter for the student to solve. Covers the requirements for Higher National Certificate, professional institution or university examinations. Each chapter begins with a summary of principles, formulae and methods.

SCHAPOSCHNIKOW, A. A. 621.385

Elektronen- und Ionenröhren (Electron and ion tubes)

Berlin: VEB Verlag Technik, 1957. pp. 430. 24 × 17cm. n.p.

This is a translation into German of a Russian general textbook on vacuum and gas-filled tubes.

SCHWARTZ, M. 621.391

Information transmission, modulation, and noise: a unified approach to communication systems*

McGraw-Hill, 1959. pp. xv, 461. 23·5 × 15cm. £4 5s. 6d.

This work intended for senior students develops qualitatively a measure of the information capacity of a system, shows that the limitations in capacity are due to the presence of energy-storing devices and to unavoidable noise fluctuations, and explores the significance of these limitations. To be reviewed.

SHIVE, J. N. 621.315.59

The properties, physics, and design of semiconductor devices*

New York: Van Nostrand, 1959. pp. xxi, 487. 23 × 16cm. £3 13s.

The first part of the book deals with the nature and properties of semiconductors, thermistors, Varistors, semiconductor photoelectric cells and transistors and with their uses. The second part is a treatise on the physics of solids and its applications to the design of semiconductor devices. The author is with Bell Telephone Laboratories. Reviewed in November 1959 *Journal*, p. 665.

SMITH, G. W., and WOOD, R. C. 518.5

Principles of analog computation*

McGraw-Hill, 1959. pp. viii, 234. 24 × 15·5cm. £2 18s.

Deals with the type of problems which can be solved by analogue computers and the methods to be used, with examples in the fields of servomechanisms and particle dynamics. To be reviewed.

OTHER PUBLICATIONS

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
ELECTRICAL ENGINEERING DEPARTMENT

12th annual conference for protective relay engineers, 13–15 April 1959

Texas: Agricultural and Mechanical College of Texas, 1959. pp. 173. 29 × 23cm. n.p.

BRITISH BROADCASTING CORPORATION

Transistor amplifiers for sound broadcasting by S. D. Berry. Engineering Division Monograph No. 26

London: B.B.C., 1959. pp. 19. 28 × 22cm. 5s.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

11th survey of electric power equipment. Situation and prospects as at 1 January 1958

Paris: O.E.E.C., 1958. pp. 106. 27 × 21cm. 10s.

Trend of the selling price of electricity and its relation to the financing of new plant

Paris: O.E.E.C., 1958. pp. 71. 27 × 21cm. 10s.

THIRUP G.

Studies on networks with periodically variable elements

Copenhagen: Jul. Gjellerups Boghandel, 1959. pp. 107. 23 × 15·5cm. n.p.

UNITED NATIONS
ECONOMIC COMMISSION FOR EUROPE

The electric power situation in Europe in 1957

Geneva: United Nations, 1959. pp. 77. 27·5 × 21·5cm. 3s. 6d.

Improved control of fluidized beds

THREE research scientists of the United Kingdom Atomic Energy Authority have devised apparatus which is claimed to give a more trouble-free and accurate indication of conditions prevailing in fluidized-bed processing equipment than earlier probe devices based on electrostatic or pneumatic systems.

The new apparatus measures the heat-transfer coefficient within the fluidized bed in the region of an electrically heated probe.

The probe is maintained at a higher temperature than the bed and means are provided to measure the power fed to the probe to keep it at constant temperature. Any perturbation in the fluid surrounding the probe is reflected by a fluctuation in the power supplied to the latter.

Fluidized-bed operations, suited as they are to continuous processing, are steadily gaining ground in many sectors of the chemical industry.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card

January 1960

MSU **5** *Tuesday* H. J. H. SKETCH, B.SC.(ENG.), P. A. SHAW, B.SC.(ENG.), *and* R. J. K. SPLATT 'New method for observing the phenomena of commutation' (paper 2955M) *synopsis:* June 1959; PROF. J. C. PRESCOTT, D.ENG., *and* A. K. EL-KHARASHI, B.SC. 'Method of measuring self-inductances applicable to large electrical machines' (paper 2871M) *synopsis:* April 1959 (p. 243) (Joint Meeting)

O **7** *Thursday* H. G. BELL, M.SC.TECH. Second Hunter Memorial Lecture 'The protection of electrical systems'‡

MED **8** *Friday* PROF. R. WOOLMER, F.F.A.R.C.S., V.R.D., *and* D. W. HILL, M.SC., will open a discussion on 'Electrical and electronic techniques in respiratory research'* (at 6 p.m., tea at 5.30 p.m.)

E **11** *Monday* G. G. GOURIET *and* G. F. NEWELL 'Quadrature network for generating vestigial-sideband signals' (paper 3054E) *synopsis:* October 1959; PROF. D. G. TUCKER, D.SC. 'Input impedance of rectifier modulators' (paper 3187E) *synopsis:* see p. 727; D. P. HOWSON, B.SC., *and* PROF. D. G. TUCKER, D.SC. 'Rectifier modulators with frequency-selective terminations, with particular reference to the effect of even-order modulation products' (paper 3051E) *synopsis:* see p. 727

S **13** *Wednesday* E. C. ROGERS, M.SC., *and* D. J. SKIPPER, B.SC.(ENG.) 'Gaseous-discharge phenomena in high-voltage d.c. cable dielectrics' (paper 3144S) *synopsis:* see p. 727

U **14** *Thursday* I. F. DAVIES, B.SC., *and* D. DUNTHORNE, B.SC. 'Application of power transistors to the operation of gas-discharge lamps from d.c. supplies' (paper 3192U) *synopsis:* see p. 727

U **15** *Friday* Section dinner-dance (at the Café Royal at 7 for 7.30 p.m.)

I **18** *Monday* W. HOLTTUM, M.ENG., will open a discussion on 'Reliability and economy of cable installation'*

M **19** *Tuesday* C. G. MAYO, M.A., will open a discussion on 'Superseding the ratio arms in a.c. bridges'†

ED **20** *Wednesday* J. G. HENDERSON, B.SC., will open a discussion on 'One approach to generalized machine analysis'* (at 6 p.m., tea at 5.30 p.m.)

M **20–21** *Wednesday–Thursday* (in co-operation with the British Computer Society, under the aegis of Group B of the British Conference on Automation and Computation) Discussion meetings on 'Managerial and engineering aspects of reliability and maintenance of digital-computer systems' (all wishing to attend are required to register; full details and registration forms are obtainable from the Secretary of The Institution)

E **27** *Wednesday* A. CLOW, M.A., D.SC., F.R.S.E. Lecture on 'Oral presentation of scientific material'†

O **28** *Thursday* A. W. LINES, B.SC., PH.D. Lecture on 'Radiocommunications by means of satellites'‡

E **29** *Friday* R. B. DYOTT *and* C. R. RUSSELL. Lecture on 'Beam-type parametric amplifiers: some aspects of design and use'†

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

British Nuclear Energy Conference

THE British Nuclear Energy Conference was established in 1955 by The Institutions of Civil, Mechanical, Electrical and Chemical Engineers and The Institute of Physics. It is a collaborating and co-ordinating rather than a controlling body, and it is true that the inelegant word 'consortium' would have defined it more clearly. Its object is the advancement and dissemination of knowledge covering the applications of nuclear energy and ancillary subjects. The Conference obtains papers dealing with the theory and practice of the control and use of nuclear energy and arranges for their presentation and publication; and it promotes meetings, symposia and conferences on a national and international basis.

General meetings sponsored by the individual constituent societies (now increased to 12) are also included in the programme of the B.N.E.C. The societies arrange for the presentation of papers relevant to their own particular aspects of nuclear energy, and members of any of the 12 societies may attend and participate in meetings so sponsored.

The Conference publishes the *Journal of the B.N.E.C.* four times a year. It contains papers presented and discussions arising at meetings of the Conference and of the constituent societies and provides between two covers a complete record of all the significant developments in the field of nuclear energy.

The *Journal of the B.N.E.C.* is available for sale to the general public but preferential rates of subscription apply to members of the constituent societies. These societies are: The Institution of Civil Engineers, The Institution of Mechanical Engineers, The Institution of Electrical Engineers, The Institute of Physics, The Institution of Chemical Engineers, The Institute of Metals, The Iron and Steel Institute, The Institute of Fuel, and The Joint Panel on Nuclear Marine Propulsion (comprising The Institute of Marine Engineers, The Institution of Naval Architects, The Institution of Engineers and Shipbuilders in Scotland, and The North East Coast Institution of Engineers and Shipbuilders).

For members the annual subscription for the *Journal of the B.N.E.C.* is 30s. post-free (single copies 7s. 6d each).

Details of a forthcoming meeting of the British Nuclear Energy Conference are given below

1960

JANUARY 26 *Tuesday* (5.30 p.m.)

Sponsoring society and place of meeting: The Institute of Marine Engineers, 76 Mark Lane, London E.C.3

CONTROL AND INSTRUMENTATION OF MARINE REACTORS R. Anscombe and F. Hutber

District Meetings

ARRANGEMENTS for District Meetings in January 1960 other than in the area of a local Centre

January 1960

READING (at the George Hotel, King Street at 7.15 p.m.)

18 *Monday* S. J. EMERSON, M.ENG. 'Safety in the use of electricity in the factory and in the home'

OXFORD (at the Southern Electricity Board Service Centre, 37 George Street at 7 p.m.)

20 *Wednesday* F. J. SUTTON 'Electrical installation practice'

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 19TH NOVEMBER 1959

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	895	9384	7	9
£2 to <£5	2186	6035	12	7
under £2	26509	13910	5	2
		£45196	8	6

THIRD INTERNATIONAL CONFERENCE ON MEDICAL ELECTRONICS

OLYMPIA, LONDON, 21ST TO 27TH JULY 1960

THE Electronics and Communications Section with the support of the Council and in association with the International Federation for Medical Electronics are organizing the third international conference on medical electronics which will be held at Olympia, London, from the 21st to 27th July 1960. The second international conference took place in Paris from the 24th to 27th June 1959 and details were given on p. 259 of the April 1959 *Journal*. Preliminary details of the third conference appeared on p. 555 of the September 1959 *Journal*. Further information will be enclosed with the next issue of the *Journal*.

The scope of the third conference in London is indicated by the preliminary subject list: instrumentation for medicine and biology; medical electronics in space research; isotopes and radiology; ultrasonics and microwave radiation; the respiratory system; the digestive system, metabolism and biochemistry; the circulatory system; electronic aspects of sight, hearing and locomotion; and the motor and nervous systems.

It is planned to provide simultaneous translation facilities.

In association with the conference The Institution is promoting an international scientific exhibition which will be held at Olympia at the same time as the conference. At this exhibition research organizations, universities, hospitals and industrial organizations from all over the world will be invited to display their latest developments in this field.

The Institution invites the submission of papers for consideration. These are the broad classes which are acceptable:

Survey papers giving an account, in part descriptive, of knowledge in a special part of the sphere

Integrating papers which present a critical review of the progress which has led to the present practice in a particular section of one of the branches of the science

Papers recording the results of research or advanced development

Papers on medical electronics, engineering practice and achievements which present details of some new project or achievement with which the author has been concerned

Short papers dealing with practical problems or with limited aspects of a wider subject.

Short papers should be of between 1000 and 2500 words; other papers should not exceed 8000 words.

The conference will be open to all interested persons; further particulars may be obtained from the Secretary of The Institution.

THE INSTITUTION TIE

SUPPLIES of the tie and of a square (30 × 30in.) of the same design can be obtained on application to the Secretary of The Institution. The charges are as follows:

Ties:	
silk (heavy quality)	£1 3s. 6d.
Terylene	18s. 0d.
Square:	
Terylene	£2 2s. 0d.

The general appearance of the tie may be seen from the accompanying illustration.

A wavy gold line edged in red, running diagonally across the navy-blue background of the tie, represents wave motion, one of the fundamental concepts of electrical engineering which appear on The Institution's coat of arms.

A shield of light blue—by common consent the predominantly 'electrical' colour—shows a winged golden thunderbolt enclosed in a golden ring bearing golden fleurs-de-lis at the four cardinal points. This alludes to the power of electricity circumscribed and under control; the fleurs-de-lis on the encircling ring make a passing reference to the compass card and thus to our seal and to the work of Kelvin.

PRACTICAL PAPERS IN THE *PROCEEDINGS*

THE Council welcome the submission, for publication in the *Proceedings*, of short papers dealing with practical problems encountered in the development, manufacture, operation or maintenance of electrical equipment. Such papers are useful to other members facing similar problems. They may be quite short, of any length between say 500 and 2500 words. A

short practical paper has an obvious attraction for the engineer who is too busy to prepare a full-length one and it provides information in a form which readers can usually assimilate rapidly.

SUBSCRIPTIONS TO THE PUBLICATIONS OF OTHER ENGINEERING INSTITUTIONS

WE remind members of the reciprocal arrangements whereby they can obtain the technical periodicals of other engineering institutions and societies at the specially reduced rates listed below:

	£ s. d.
Institution of Civil Engineers:	
Proceedings (single issues 3s. 6d.)	2 0 0
Institution of Mechanical Engineers:	
Chartered Mechanical Engineer	2 2 6
Chartered Mechanical Engineer and separates of *Proceedings* and Automobile Division *Proceedings*	7 5 6
Chartered Mechanical Engineer and separates and bound volumes of *Proceedings* and Automobile Division *Proceedings*	10 4 6
Chartered Mechanical Engineer and bound volumes of *Proceedings* and Automobile Division *Proceedings*	8 18 6
Bound volumes only of Institution *Proceedings* and Automobile Division *Proceedings*	7 5 0
Self-binding case for the copies of *Chartered Mechanical Engineer*	13 0
American Institute of Electrical Engineers:	
Electrical Engineering	2 10 0
Transactions	4 0 0
Communication and Electronics	2 2 0
Application and Industry	2 2 0
Power Apparatus Systems	2 2 0
Associazione Elettrotecnica Italiana:	
L'Elettrotecnica	2 18 0
Alta Frequenza	2 2 0
Dansk Ingeniørforening:	
Ingeniøren	1 5 0
Engineering Institute of Canada:	
The Engineering Journal	1 9 0
Institution of Engineers, India:	
Journal	
Part I (civil and general section)	1 7 0
Part II (mechanical, electrical and general section)	1 7 0
Both the above parts	2 14 0
Single copies	2 3
Institute of Physics:	
British Journal of Applied Physics	3 0 0
Journal of Scientific Instruments	3 0 0
Both the above publications	6 0 0
Institute of Radio Engineers, America:	
Proceedings	4 17 6
Transactions of the 21 Professional Groups	35 16 6
Transactions of any single Professional Group	3 1 0
Institution of Engineers, Australia:	
Journal	3 3 0
Civil Engineering Transactions	1 4 0
Electrical and Mechanical Engineering Transactions	1 4 0
Both parts	2 8 0
Koninklijk Instituut van Ingenieurs:	
De Ingenieur	2 5 0
New Zealand Institution of Engineers:	
New Zealand Engineering	14 6
Société Belge des Électriciens:	
Bulletin	1 7 6
Société Française des Électriciens:	
Bulletin	3 15 0
South African Institute of Electrical Engineers:	
Transactions	3 0 0
Svenska Teknologföreningen:	
Teknisk Tidskrift	4 0 0
Verband Deutscher Elektrotechniker e.V.:	
Elektrotechnische Zeitschrift edition A (*ETZ-A*)	3 15 0
Elektrotechnische Zeitschrift edition B (*ETZ-B*)	1 9 0
Elektrotechnische Zeitschrift editions A and B	5 4 0
Nachrichtentechnische Zeitschrift (*NTZ*)	2 14 0

Members' subscriptions must be transmitted through the Secretary of The Institution of Electrical Engineers except those for the publications of The Institution of Mechanical Engineers which should be sent to the Secretary of that Institution and those for the *Proceedings* of The Institution of Civil Engineers which should be sent to one of the following agents:

Sir Isaac Pitman and Sons Ltd.: The Book Centre, North Circular Road, Neasden, London N.W.10; Little Collins Street, Melbourne, Australia; Pitman House, 381–3 Church Street, Toronto, Canada; 27 Becketts Buildings, President Street, Johannesburg, South Africa. Pitman Publishing Corporation, 2 West 45th Street, New York. A. H. Wheeler and Co.: Hornby Road, Bombay; 11 Clive Street, Calcutta; and 115 Elgin Road, Allahabad.

MOSCOW CONGRESS ON AUTOMATIC CONTROL

DETAILS of the first international congress of the International Federation of Automatic Control which is to be held in Moscow from the 25th June to 5th July 1960 were given on p. 48 of the January 1959 *Journal*. See also p. 704.

Members wishing to attend are asked to note that application forms for attendance are available from the Honorary

Announcements to members (continued)

Secretary, Group B, British Conference on Automation and Computation, c/o The Institution of Electrical Engineers, Savoy Place, London W.C.2.

If sufficient people register it is hoped to arrange for travel to and from Moscow, and for hotel accommodation there over the period of the congress, at reduced rates.

VACUUM SCIENCE AND TECHNOLOGY

AS a result of informal discussions between societies in this country the Joint British Committee for Vacuum Science and Technology has been formed. The committee consists of representatives from The Institute of Biology, The Institution of Chemical Engineers, The Royal Institute of Chemistry, The Institution of Electrical Engineers, The Iron and Steel Institute, The Institution of Mechanical Engineers, The Institute of Metals, The Institute of Petroleum, The Physical Society and The Institute of Physics.

The objects of the committee are:

1. To co-ordinate and help to initiate meetings in the whole field of vacuum science and technology arranged by constituent bodies.
2. To act in the collective interest of the constituent bodies by maintaining liaison with the International Organization for Vacuum Science and Technology and with national vacuum societies, and otherwise.

The Institute of Physics has agreed to provide the secretariat for the joint committee. Communications for the committee should be addressed to its Secretary at 47 Belgrave Square, London S.W.1.

CHRISTMAS HOLIDAY LECTURE

OWING to the large number of applications received no tickets are now available for the Christmas Holiday Lecture 'Colour television' by Mr. G. G. Gouriet on the afternoons of the 30th and 31st December 1959. The lecture is however to be repeated on the morning of Thursday, 31st December 1959 at 10.30 a.m. and application for tickets should be made to the Secretary of The Institution.

CORRECTION

THE Chairman of the Finance Committee of the Council of The Institution is Mr. C. T. Melling, C.B.E., M.SC.TECH., not as inadvertently stated on p. 678 of the November 1959 *Journal* Mr. G. S. C. Lucas, O.B.E., F.C.G.I.

NEW COASTAL-RADIO V.H.F. SERVICES

THE Post Office coastal-radio facilities for shipping are being strengthened by the addition of two new v.h.f. services. One was opened at the Humber (Mablethorpe) coast-radio station on the 1st December 1959 and is to be followed by a similar one starting at the Land's End station early in January 1960. The traffic-channel frequencies at Land's End are 157·35 and 161·95 Mc/s and at Humber 157·3 and 161·9 Mc/s. The calling-channel frequency at both stations is 156·8 Mc/s.

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (DECEMBER 1959)

D. B. WELBOURN, M.A., PROF. D. B. SPALDING, M.A., PH.D., AND G. L. ASHDOWN. PAPER 2913, MAY 1959 **Engineering education at the technical universities in Western Germany** *December 1959*

PROFS. H.-G. KAYSER, K. LUERENBAUM, CL. MÜLLER, R. SAUER, H. STEFANIAK AND R. WILLE. REPORT 2987, MAY 1959 **Problems of engineering education** (Report of a group of German professors who visited England) *December 1959*

G. B. HARPER. PAPER 2804S, JANUARY 1959 **Selection of insulation levels and tests for high-voltage transformers** *June 1959*

Discussion on **Operational experience at Calder Hall** before the North-Eastern Centre, the North Midland Centre, the North Staffordshire Sub-Centre and the North-Western Supply Group

Discussion on **Electrification of the U.K.A.E.A. industrial group factories** before the North-Eastern Centre, the Western Centre, a joint meeting of the Mersey and North Wales Centre and the North-Western Centre, and the Tees-Side Sub-Centre

Discussion on **Electrical installation at Calder Hall nuclear power station** before the North-Western Utilization Group

D. A. DEWISON. PAPER 2759S, DECEMBER 1958 **Electrical supplies to power-station auxiliaries** *August 1959*

Communicated discussion on **Starting of a 3-phase induction motor connected to a single-phase supply system**

PROF. F. C. WILLIAMS, O.B.E., D.SC., P.DHIL., E. R. LAITHWAITE, M.SC., PH.D., AND J. F. EASTHAM, M.SC. PAPER 3036U **Development and design of spherical induction motors** *November 1959*

Communicated discussion on **Application of a variable-reactor/capacitor combination for reversing and controlling the speed of polyphase induction motors**

D. O. BISHOP, PH.D., B.SC.(ENG.), AND G. S. BROSAN, PH.D., B.SC.(ENG.). PAPER 2861U, MARCH 1959 **Electromagnetic variable-ratio torque convertor** *June 1959*

Discussion on **Electricity in modern commercial horticulture** before the Mersey and North Wales Centre

J. W. PANNELL, M.SC.(ENG.). PAPER 3089S **Alternator with field-form envelope control** *November 1959*

J. E. GOULD, B.SC. PAPER 3069M **Progress in permanent-magnet materials** *December 1959*

Communicated discussion on **Application of transistors to phase-comparison carrier protection**

Discussion on **Investigations of power-follow-current phenomena using a synthetic power source** and **Impulse initiation of arc discharges** before the Mersey and North Wales Centre

Discussion on **Recent developments in medium-voltage h.b.c. fuse links** before the South Midland Supply and Utilization Group

Discussion on **Electrical floor-warming** before the North-Western Utilization Group, the Southern Centre, the Western Centre, the South-West Scotland Sub-Centre, the Mersey and North Wales Centre, the South Midland Centre and the North Staffordshire Sub-Centre

Discussion on **Earthing of low- and medium-voltage distribution systems and equipment** before the Northern Ireland Centre, the Irish Branch, a joint meeting of the Western Supply Group and the South-Western Sub-Centre, and the Sheffield Sub-Centre

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (NOVEMBER 1959)

See the Journal for November 1959, p. 667

PART C. MONOGRAPHS (SEPTEMBER 1959)

See the Journal for September 1959, p. 557

BULLETIN OF THE SECTIONS

UTILIZATION

The new look

For two reasons the meeting at Savoy Place on the 15th October 1959 was notable. It was not only the opening meeting of the session when the new Chairman, Mr. T. E. Houghton, delivered his Address but it was for many present the first experience of the Lecture Theatre following its 'new look' treatment.

The new lay-out, décor and seating arrangements were unfamiliar after the austere surroundings to which we had been used for so many years. The theatre-like seats are undoubtedly a great improvement both in colour and comfort on the old drab benches. One wonders whether the hitherto legitimate excuse of bad ventilation for nodding during the reading of an abstruse paper will now be replaced by the more doubtful one of being too comfortable. Another intriguing innovation was the raising and lowering, with the action of a safety curtain, of the covering for the lantern screen.

Electricity and heavy chemicals

Mr. Houghton spoke on the electrical engineer and the heavy-chemical industry. The annual consumption of electricity by the chemical industry exceeds 10000 million kWh and is increasing rapidly. The cost of power is often a large fraction of the total cost of the product, and the case for private generation should accordingly be exhaustively investigated. If process steam is also required some form of back-pressure or pass-out turbo-alternator should be used.

Electrolytic processes call for large and reliable d.c. supplies together with a high load factor. In consequence very short periods are available for maintenance of the electrical plant. Motor-convertors have been used in this country while Germany and the United States have favoured mercury-arc rectifiers. Mechanical contact rectifiers have also been adopted. More recently semiconductor rectifiers based on germanium and silicon have proved quite successful and may be preferred in future for electrolytic service.

A 39 MVA calcium-carbide furnace was recently commissioned. The distribution lay-out had to ensure a constant supply, and special precautions had to be taken in inflammable conditions.

The Address was illustrated by a number of slides.

Mr. J. M. Ferguson proposed a vote of thanks to the new Chairman.

The retiring Chairman, Mr. R. A. Marryat, then vacated the chair in favour of Mr. Houghton. Mr. J. Vaughan Harries voiced the feelings of the Section in proposing their thanks to Mr. Marryat for all the hard work he had put in during his term of office which he had carried out in his own quiet and unassuming way. R. H. R.

ELECTRONICS AND COMMUNICATIONS

Two on waveguides

At a meeting at Savoy Place on the 2nd November 1959 Dr. A. E. Karbowiak presented a paper on the classification of waveguide modes and was followed by Mr. L. Lewin with a contribution on quasi-optical methods at millimetre wavelengths. A short article based on Dr. Karbowiak's paper will be found on p. 715. Mr. R. J. Halsey was in the chair and 30 persons were present—a comparatively small number which reflected the rather specialized nature of the subjects considered.

Both papers were well presented and they were followed by quite an animated discussion in which Prof. H. M. Barlow, Dr. J. Brown, Mr. R. A. Waldron and the two authors took part. There seemed to be a consensus of opinion that while Dr. Karbowiak had made a number of important points in his paper he had not really succeeded in clarifying the position by the classification he proposed for the various waveguide modes. The basis of Mr. Lewin's selection in recommending forms of waveguide for the millimetre part of the spectrum was also the subject of questions, attention being called to the possibilities of the single-wire transmission line in this application.

The evening emphasized the need to discuss matters of this kind, and although the group concerned was a small one the ideas put forward helped very much in forming a balanced view of the problems examined. H. M. B.

Travelling-wave parametric amplifiers

Widespread interest in the new amplifying techniques being developed for frequencies around 100 Mc/s and above was demonstrated by the audience which crowded the Tea Room at Savoy Place on the 9th November 1959. Four papers were presented: 'Theory of the travelling-wave parametric amplifier' by Prof. A. L. Cullen; 'Saturation effects in a travelling-wave parametric amplifier' by A. Jurkus and P. N. Robson; 'The gain of travelling-wave ferromagnetic amplifiers' by P. J. B. Clarricoats; and 'Some properties of travelling-wave resonance' by J. R. G. Twistleton. Short reviews are given on pp. 712–14.

Prof. Cullen opened with a lucid account of the physical mechanism of a parametric amplifier and indicated the principal features of his theoretical analysis of travelling-wave amplifiers using semiconductor diodes. A more detailed discussion of one particular feature, the saturation of the amplifier, was given by Mr. Robson.

Dr. Clarricoats explained the mechanism of a travelling-wave amplifier using ferrites and gave reasons for supposing

that this amplifier will be suitable for operation only in pulsed conditions.

The final paper on travelling-wave resonance in waveguide-ring-circuits was not specifically concerned with amplifiers, but Mr. Twistleton pointed out that his theory might be applied to furthering our knowledge of the mechanism of magnetrons. A feature of the meeting was the care taken by the speakers in outlining the fundamental principles on which their theories were founded and this paved the way for a good discussion.

Theory and practice

The discussion centred on two main points: the first related to the necessary approximations made in the theoretical analysis and to the extent to which these were consistent with practical devices and the second pointed to the practical difficulties involved in constructing parametric amplifiers.

Mr. A. F. H. Thompson suggested an alternative mode of operation for the ferromagnetic amplifier which might overcome some of the problems mentioned in Dr. Clarricoats's paper but went on to describe a new absorption mechanism, associated with spin waves in the ferrite, which raised further problems. Mr. R. W. White and Dr. R. Dunsmuir questioned the validity of representing the semiconductor-diode amplifier by a continuous circuit when in practice the diodes are connected at discrete intervals and suggested that this might lead to different results.

Other speakers mentioned the modifications to the results which might ensue but there was a lack of agreement on the details.

Mr. J. Dain remarked that as a valve engineer he did not approve of semiconductor amplifiers and furthered his interest in electronic devices by pointing out that the electron-beam parametric amplifier was free from saturation effects.

The authors stressed the idealized nature of the theoretical treatment. It is clear however that this theory has helped towards making the parametric amplifier a useful practical device.

The Chairman, Mr. T. B. D. Terroni, said that the fact that four papers which even ten years ago would have been 'relegated to the obscurity of mathematical journals' could attract such a large audience was indicative of the progress being made by electronics engineers. J. B.

LONDON REPORT

EDUCATION DISCUSSION CIRCLE

'Men are never so likely to settle a question rightly as when they discuss it freely'

DR. F. T. CHAPMAN might well have quoted Macaulay when, with other like-minded enthusiasts, he formed with the Council's support the first Education Discussion Circle in London and became its first Chairman. Under his guidance the Circle has provided a forum for those with fresh ideas on the teaching of many phases of electrical engineering at university and technical-college level, and there has been the occasional lecture on developing subjects to stimulate some to fill in gaps in their own technical knowledge.

At the opening meeting of the Circle at Savoy Place on the 14th October 1959 the new Chairman, Dr. K. R. Sturley, explained that the Panel had accepted with regret Dr. Chapman's contention that after 12 years in the chair he should make way for a younger man. The Chairman paid him a warm and sincere tribute and expressed the hope that the Panel would have the advantage of his guidance and advice for many more years yet.

Exposure to industrial conditions

Evidence of the broadening of the Circle's activities, if this were needed, was provided by the evening's discussion 'Graduate training in industry' opened by Mr. W. H. Taylor. He outlined the difficulties of deciding on the best type of training for graduates, emphasizing the need to steer a middle course between the haphazard 'exposure to industrial conditions' method and the overplanned regimentation which made no allowance for the individual characteristics of the student. It was much easier to organize a course which had a definite objective, e.g. training a graduate for a specific job, than it was to arrange for him to find his feet in industry and to discover what he was best fitted to do.

If the main objective were to make a graduate immediately available for useful work a very short term of training would suffice but Mr. Taylor asserted that the aim should be to develop his full potentialities and to think in terms of his probable value in five years' time. He accepted as a general pattern the recommended threefold plan of basic, general and professional training and regarded the professional period as the most important and sometimes the most difficult to plan. The training officer must know well the departments into which the graduate would be sent and he should make an attempt to assess their value in giving training.

In the brisk discussion that followed some argued that no training at all was necessary—one said he had tried this and had failed to recruit graduates!—while another stated that even if The Institution's recommendation for a two-year training period were dropped his firm would wish to continue it. A plea was made that the Institution booklet on training should be rewritten to make it more understandable to non-technical managements and to allow more room for manœuvre by those responsible for training.

Some speakers felt that the training officer shouldered executive responsibility more properly within the province of management but others thought he had to go beyond the advisory stage. The difficulties of giving graduates satisfactory

training in a small company were referred to and the group training scheme was recommended as a solution. The placing of physicists in an engineering training scheme was said to present no difficulties. K. R. S.

DISTRICT MEETING AT READING

Enough is as good as a feast

MR. FORBES JACKSON presided at the first and well attended meeting of the session at the George Hotel, Reading, on the 19th October 1959 when Mr. C. A. Belcher gave a talk on the provision of adequate installations in small houses and flats.

After discussing the various systems of wiring Mr. Belcher stressed that the steadily increasing use of domestic electrical aids is demanding a liberal conception of adequate socket-outlet facilities and that this is necessary to avoid the often dangerous improvisations that some householders are driven to adopt in their endeavours to make all their electrical ends meet.

He described the results of a sociological study carried out in the London area which showed that an allocation of three socket-outlets in the living room, one in the kitchen (apart from the cooker-control unit), two in each of the larger bedrooms and one in the small bedroom was about the minimum adequate basic allowance for flats and maisonettes.

The cost of such an installation would be less than 2% of the total cost of the dwelling. A very desirable amenity as distinct from essential basic needs could be provided by the substitution of a double socket-outlet for one of the single points in each room, and the effect on total cost would be an increase of about 0·1%.

The talk stimulated a long and interesting discussion which not unexpectedly centred mainly on floor-warming and methods for the control of off-peak space-heating.

The speaker was warmly thanked for his talk and for the helpful answers given to the many questions by Mr. E. W. Weaver. H. B.

DISTRICT MEETING AT OXFORD

Modern generating stations

A MEETING with Mr. V. Brice in the chair was held at the Southern Electricity Board's District Office on the 11th November 1959 when Mr. A. E. Hawkins, chief operational engineer of the Central Electricity Generating Board, read his paper 'Modern coal-fired power stations'.

Mr. Hawkins reviewed the growth in demand up to the present day and explained the necessity of establishing the National Grid in 1926. His talk was amply illustrated by slides indicating future trends and the methods by which the C.E.G.B. would deal with increases in consumption. He explained that the nuclear power stations would supplement the coal-fired power stations rather than replace them.

An extremely interesting film showed the construction of Castle Donington, the latest coal-fired station to be put into commission.

An interesting discussion ranged from the extent to which Area Boards should top off the Grid system to the operation of super-critical boilers. D. T. H.

News from the Centres

MERSEY AND NORTH WALES CENTRE

Starting the session

MR. T. A. P. COLLEDGE began his year of office as Chairman of the Centre on the 5th October 1959 when he presented his Address 'The development of the telephone system in Great Britain' at the Royal Institution, Liverpool.

Annual dinner

The annual dinner at the Grosvenor Hotel, Chester, on the 2nd November 1959 was attended by the President, Sir Willis Jackson. Guests included Dr. Charles Evans, Principal of the University College of North Wales and renowned Everest climber; the Mayor of Chester, Alderman H. W. Talbott; the Bishop of Chester, Dr. G. Ellison; the Rev. L. F. Harvey, Headmaster, King's School, Chester; Mr. W. K. Brasher; and representatives of sister institutions and kindred societies and of other Centres and Sub-Centres.

Proposing the toast of The Institution Dr. Evans paid tribute to the contributions made by the profession to the welfare of the community. He had realized the value of communications during his expeditions to the Himalayas; in general surgery effective lighting was of paramount importance; and in brain surgery cauterizing by electricity to stop bleeding had made possible great advances.

Replying, Sir Willis Jackson referred to professional training and said that specialists should see themselves as part of the broader corporate body of electrical engineers. In the absence of supporting practice, theory was likely to be no more than a scientific abstraction. Without supporting theory,

At the annual dinner of the Mersey and North Wales Centre

Left to right: Dr. Ellison, Prof. Meek, Sir Willis Jackson, Alderman Talbott, Mr. Colledge, Mr. Harvey, and Mr. S. Towill

practice was likely to degenerate into a succession of *ad hoc* decisions and precarious uncertainties.

Sir Willis spoke of the deficiency in good training facilities to match good academic teaching and deplored the fact that we were unable to provide practical training for many of the oversea students who had attended our universities and colleges. The solution lay in the smaller and more specialized concerns co-operating to supplement the facilities for training given by the larger organizations.

Prof. J. M. Meek, Past-Chairman of the Centre and Dean of the Faculty of Engineering at Liverpool University, proposed the health of the guests and Mr. Harvey responded.

E. W. A.

NORTH MIDLAND CENTRE

Computers

OVER 100 members and guests attended the sixth District Meeting at the School of Signals, Catterick Camp, on the 21st April 1959 to hear a paper by Mr. C. H. Devenolde on 'Computers—their techniques and capabilities'. The chairman, Lt.-Col. M. A. Philp, expressed the thanks of all present to the Honorary Secretary, Maj. A. T. Burrows, who was soon to leave Catterick and who had done a great deal of work in arranging the meetings and lectures during the previous two years.

Mr. Devenolde explained how costs and speed of operation of computer basic elements were being improved. Further improvement was likely as the result of work now in progress on the cryotron and on new methods of providing fast-access memory storage. In the discussion great interest was shown in the possibilities of co-ordinated systems of computers linked by a communication network. The many questions were answered capably by the speaker.

Annual golf match

The annual golf match was held at Sand Moor Golf Course on the 26th May 1959 when 62 people played. All thoroughly enjoyed themselves on a course in perfect condition with the weather in its kindest mood. No less enjoyable was the dinner presided over by the Centre Chairman, Mr. J. D. Nicholson. Mr. A. J. Coveney announced that the winner of the Woodhouse Challenge Cup was the Chairman, which he believed was unique in the history of the competition.

After presenting the prizes the Chairman thanked the Club officials for the excellence of the arrangements and Mr. W. Plumb who had travelled from Southport to run the auction in his inimitable style for the benefit of the Benevolent Fund.

Electrical engineering at Redbrick University

The opening meeting of the 1959–60 Session was held on the 6th October 1959 under the Chairmanship of Mr. J. D. Nicholson, approximately 100 members being present. The Chairman welcomed four new Corporate members and explained to them the aims of The Institution. An Institution Premium Certificate was presented to Fl.-Officer D. Marshall for his paper 'The protection of 132 kV transmission networks' read before the Graduate and Student Section on the 11th March 1958 (to be reviewed in the *Journal*) and the Bailey Memorial Prize to Mr. P. A. D. Sheen for his paper 'Electric winders' read before the Graduate and Student Section on the 22nd April 1958.

The Chairman then called on Prof. G. W. Carter to deliver his Inaugural Address which proved to be an exceedingly interesting account of the historical development of civic universities, their government, administration, teaching aims and methods. An article based on the Address will appear in the *Journal* in due course. The vote of thanks to Prof. Carter was proposed by Mr. Coveney who said he was particularly interested to hear about the breakaway from mechanical engineering and how it was proposed to integrate the subsequent development of electronics with electrical engineering.

Seconding, Mr. W. J. A. Painter said that Prof. Carter had provided many lessons which could be applied with profit to industry.

Dr. E. C. Walton then made his customary appeal on behalf of the Benevolent Fund which realized £15 4s.

Mr. Nicholson after thanking the Committee and members for their support said that the Centre had always maintained close touch with the University of Leeds and it gave him great pleasure to invite Prof. Carter to take the chair. Prof. Carter thanked the retiring Chairman and asked Dr. G. W. Patchett to propose a vote of thanks.

Dr. Patchett said that Mr. Nicholson had put his heart and soul into the job of Chairman which had probably been the hardest task of any Chairman in the Centre for many years because of the Institution Summer Meeting held this year in Harrogate.

Prof. Carter presented the Certificate of Chairmanship and a copy of the History of The Institution to the retiring Chairman who suitably responded.

H. H.

SHEFFIELD SUB-CENTRE

Magnetism and loyalty

WAS it magnetism or loyalty that drew almost a record attendance to the opening night of the 1959–60 Session on the 21st October 1959 in spite of a City bus strike and the first rain in months doing their best to hamper many?

Certainly the welcome given to our new Chairman, Mr. F. G. Tyack, augurs well for another year of growth and interest. His Address 'Permanent magnets and the electrical engineer' was as appropriate as it was technically thorough and maintained the high standard set in recent years by his predecessors in office. Mr. H. Anderson proposed the vote of thanks to the new Chairman.

Dr. F. A. Benson, the retiring Chairman, gave a telling account of the responsibilities that now fall on the shoulders of a Sub-Centre Chairman and mentioned that he had attended 144 committee meetings during the 147 working days of his year of office.

Dr. O. I. Butler wittily proposed a vote of thanks to Dr. Benson—or was it to Mrs. Benson whom he described as a

lady of great charm and forbearance; compared with her a 'golf widow' was a much married lady.

Mr. F. Seddon, the Sub-Centre Treasurer, made an appeal for the Benevolent Fund.

Both the Chairman and Dr. Benson made special reference to the lanternists, Mr. E. C. Parsons and Mr. W. Garton, who have given their services free (including the lantern) for over 20 years. This is a remarkable record in this day and age when doing something for nothing is becoming so rare, and the Sub-Centre is proud to have such loyal and generous helpers.

Mr. Tyack in Brigg

The session's first meeting of the North Lincolnshire District was at the Angel Hotel, Brigg, on the 26th October 1959 when Mr. Tyack repeated his Sub-Centre Chairman's Address. His comprehensive survey of the permanent-magnet world provided much food for thought on a subject not often discussed. Mr. N. L. Evans proposed the vote of thanks.

As this was the District Annual General Meeting the Convener and Committee retired, were suitably thanked for their services by Mr. B. Ness, and were unanimously re-elected to their previous offices on the proposition of Mr. J. L. Gaskell.

J. W. S.

SCOTTISH CENTRE

Poles and precipitators

THE South-East and South-West Scotland Sub-Centre Chairmen's Addresses were delivered in Edinburgh and Glasgow respectively on the 20th and 21st October 1959 respectively. Both Chairmen provided not only excellence of presentation but also originality of subject-matter.

In Edinburgh Mr. D. M. Thornton discussed the problems of supplying electricity to the very sparsely populated areas in the hill country of the Border where an engineer must also be something of a farmer, a lawyer and a geologist. The Address was illustrated by a series of magnificent colour slides taken by Mr. Thornton showing the beauty and grandeur of the area. In each picture however there was just discernible an overhead line running up a valley or round the shoulder of a hill to supply an isolated farmstead. Another series of slides showed 'logging' operations in which wood poles had to be transported to a site by floating them down a loch.

In Glasgow Mr. J. E. Sayers spoke on 'Electrostatic precipitators' and in describing the design and development of equipment made what might have seemed a somewhat specialized paper into one of the most interesting addresses ever heard in the Sub-Centre. The retiring Chairman, Mr. W. Adam, when introducing Mr. Sayers referred to the fact that the new Chairman's father, the late Mr. J. E. Sayers, was Honorary Secretary of the Scottish Centre from 1907 to 1913 and Chairman in 1920–21.

Electronics and measurement

Conditions in Scotland since the war have led to the development of many light-current industries. Institution members interested in these fields have for some time been pressing for the formation of a light-current Group within the Scottish Centre. During recent sessions a series of exploratory meetings have been held in both Glasgow and Edinburgh at which light-current papers have been read.

The success of these has now culminated in the formation of an Electronics and Measurement Group attached to the Centre. Its affairs are at present organized by an interim committee of which Mr. J. Stewart is Chairman and Mr. D. R. Rollo Honorary Secretary. The inaugural meetings of the Group were successfully held in Glasgow and Edinburgh on the 27th October and 11th November 1959 when Mr. H. J. H. Sketch read the paper by himself, Mr. P. A. Shaw and Mr. R. J. K. Splatt 'A new method for observing the phenomena of commutation' (for synopsis see June 1959 *Journal*, p. 386).

E. O. T.

Local Honorary Treasurers of the Benevolent Fund

East Midland	*H. J. McLean*
Irish Branch	*A. Harkin, M.E.*
Mersey and North Wales Centre	*D. A. Picken*
North-Eastern Centre	*J. F. Skipsey, B.Sc.*
North Midland Centre	*E. C. Walton, Ph.D., B.Eng.*
Sheffield Sub-Centre	*F. Seddon*
North-Western Centre	*E. G. Taylor, B.Sc.(Eng.)*
North Lancashire Sub-Centre	*H. Charnley*
Northern Ireland Centre	*G. H. Moir, J.P.*
Scottish Centre	*R. H. Dean, B.Sc.Tech.*
North Scotland Sub-Centre	*P. Philip*
South Midland Centre	*Capt. J. H. Patterson, R.A.*
Rugby Sub-Centre	*P. G. Ross, B.Sc.*
Southern Centre	*G. D. Arden*
Western Centre (Bristol)	*A. H. McQueen*
Western Centre (Cardiff)	*E. W. S. Watt*
West Wales (Swansea) Sub-Centre	*O. J. Mayo*
South-Western Sub-Centre	*W. E. Johnson*

Electrical equipment in new marshalling yard

BRITISH Railways have begun work on a new marshalling yard at Carlisle so that goods traffic can be transferred more quickly between England and Scotland.

It is expected that the yard will be in operation in 2½ years' time. It will handle some 258 freight trains a day. It will have 101 sorting sidings, 18 reception sidings and 20 departure sidings.

Electrical equipment will include press-button automatic route-setting of all points between the reception sidings and the main sorting sidings; colour-light signal control of humping operations; a modern communication system comprising wide loudspeaker coverage, an automatic telephone system, internal omnibus circuits, circuits connecting selected points with Carlisle control room, extensions to selected points from Carlisle Citadel exchange, a teleprinter circuit between Carlisle telegraph office and the yardmaster's office, and radiocommunication between shunting engines and control towers; an electric-clock system with synchronized dials; and centralized signalling for the control of movements into, out of and within the yard area.

News from abroad

QUEENSLAND OVERSEA COMMITTEE

Accepting criticism

On the 15th October 1959 a meeting of about 40 people was held in Brisbane at which Dr. M. Darveniza dealt with some aspects of his experience in dielectric research at Queen Mary College, University of London, and of his present work in the High-Voltage Laboratory of the University of Queensland. Mr. A. S. Faulkner was in the chair.

The speaker discussed the problem of electric discharges in insulating liquids and gave an account of the influence of various experimental parameters on the electric strength of transformer oil. He indicated the amount of impurity such as air and water which may be found in solution in the oil and its effect on the electric strength.

Other experimental factors influence the work of the University of Queensland High-Voltage Laboratory as a testing authority, e.g. temperature, the impulse-testing technique, and the prestressing of oil-insulated equipment. These topics were considered in the light of the accepted procedures for impulse tests on h.v. transformers and cables.

Regarding his work at Queen Mary College Dr. Darveniza emphasized that preparation is desirable before participation in that type of research programme. Speaking from his own experience and from observation of possibly less fortunate scholars he advocated a combination of industrial experience and local postgraduate research before the undertaking of such higher studies. One provided practical experience of industrial problems, and the other taught discipline in ideas and methods befitting a research student.

Acquiring a technique in research is imperative but the research student does not work in isolation in a laboratory. He must have contact with industrialists, and his earlier experience would bridge the gap between industry and the laboratory. Furthermore he must learn to accept criticism and establish criteria by which it may be judged. Local postgraduate work can instil the value of criticism, and the rougher experience in industry can teach its acceptance.

Circuit-breakers

On the 22nd October 1959 a well attended meeting heard an address by Dr. Hochrainer on 'Development of extra-high-tension air-blast circuit-breakers'.

He explained the fundamentals of circuit-breaking by reference to oscillographs of typical conditions. To prevent reignition of the arc it is necessary to restore the insulation between the contacts, remove ionization and cool the area.

He traced the development of air-blast switchgear and commented on the advantages and disadvantages of axial- and cross-flow air currents. A combination of these two currents is used in the switchgear described.

Dr. Hochrainer referred to the synthetic testing of very-high-voltage switchgear whose breaking capacity cannot be determined in the full scale because of the limitations of test plant. W. I. G.

GIBRALTAR JOINT GROUP

Large pipeline projects

The first meeting of the current session was held on the 7th October 1959 at the Calpe Institute. Thirty members attended as well as a number of distinguished guests including the Governor, the Colonial Secretary and the Mayor.

The Chairman, Capt. J. G. Watson, M.I.E.E., R.N., formally announced the recognition of the Joint Group by the three parent institutions and spoke of the responsibilities and privileges which this involved. The Group now contained 35 official members, all of whom were taking part in the activities. He introduced the new Chairman, Mr. E. V. Andlaw, M.B.E., M.I.MECH.E., M.I.E.E.

Mr. Andlaw spoke of his pleasure in taking office for the first full session of the Group after its official recognition. He expressed the thanks of the members to the retiring Honorary Secretary, Lt.-Col. R. A. Lindsell, M.C., M.I.E.E., R.E., who was shortly returning to England.

Mr. Andlaw then introduced Mr. A. C. Hartley, C.B.E., B.SC. (ENG.), President-Elect of the Institution of Civil Engineers and Past-President of the Institution of Mechanical Engineers, who was making a special visit to Gibraltar for the meeting, saying what a privilege it was to have so eminent an engineer to speak to the Group. Mr. Hartley delivered a special version of his James Clayton Lecture on 'Large pipeline projects' illustrated by slides and film and answered a number of questions from the audience. R. A. L.

SINGAPORE/MALAYA JOINT GROUP

Visit to Weld Quay

On the 3rd October 1959 about 50 people including 23 members of the Group paid a visit to the building site of the new Government offices at Weld Quay, Penang.

The executive engineer of the Public Works Department; the civil engineer, Sime Darby; and a representative of the architects gave short talks on their respective parts in the project, and the party then toured the site. T. C.

OVERSEA ATTENDANCE REGISTER

DURING the period 16th September to 14th November 1959 these members called at the Institution building and signed the Attendance Register of Oversea Members:

AIMER, H. K. (Wellington, New Zealand)
AKINDELE, T. O. (Lagos, Nigeria)
BALL, D. H. (Kuala Lumpur, Malaya)
BANNERJEE, H. (Calcutta)
BASEDEN, C. (Arcachon, France)
BELLE, A. D. (Nicosia, Cyprus)
BISHOP, T. R. J. (Johannesburg)
BOCCALERO, A. (Milan)
CATTLE, W. F. (Salisbury, Southern Rhodesia)
COTTARIS, F. S. A. (Dar es Salaam, Tanganyika)
FARNLEY, A. W. (Lagos, Nigeria)
FARRER, J. A. (Lagos, Nigeria)
FROUD, M. (Paris)
HAREVEN, D. (Haifa, Israel)
HARRIS, A. (Fribourg, Switzerland)
HARRIS, E. G. (Wellington, N.Z.)
HILL, D. S. (Hong Kong)
LAETT, H. A. (Bern, Switzerland)
MATHUR, P. L. (Calcutta)
MAYLIN, R. F. (Baghdad, Iraq)
MURPHY, B. (Brussels)
MYERS, A. J. (Kumasi, Ghana)
MYERS, H. (Calcutta)
PANCHOLI, H. (Nairobi, Kenya)
PICKETT, E. S. J. (Jamaica)
ROBINSON, G. H. T. (Kaduna, Nigeria)
ROOTS, W. K. (Santa Clara, California)
SCOTT, E. (Kuwait)
SHISHINI, M. E. (Cairo)
STOKES, H. W. (Toronto)
TRAUB, H. (Johannesburg)
VIGNES, F. (Vacoas, Mauritius)
WEISLITZER, J. (Ramot Remez, Israel)
WILLOUGHBY, G. P. (Nairobi, Kenya)

INDEX TO THE JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 5 1959

NOTE. In the index, titles of articles, papers, lectures and books are printed in italic type.

Papers and monographs of the *Proceedings* figure in these features of the *Journal*: **A review of the *Proceedings*, Parts A and B; Papers and monographs published individually this month; Bulletin of the Sections; London report;** and **Contents of the current *Proceedings*.** To ease reference and to save space all these entries are brought together and listed in alphabetical order of authors' names under one combined heading: ***Proceedings* papers and monographs.** There is however a separate additional detailed indexing of **A review of the *Proceedings*, Parts A and B.** Papers and monographs of the *Proceedings* do not therefore, unlike the *Journal* articles proper, appear in the main index alphabetically under title and author. Similarly the names of deceased Members are given only under the heading **Obituary,** particulars of letters only under **Correspondence,** and details of books reviewed only under **Some recent books.**

A

Abroad, news from 131, 268, 343, 406, 494, 563, 676, 744

Acceptance sampling 700

Accessions, Library 115, 181, 255, 329, 394, 482, 545, 608, 665, 733

Accounts for 1958 450

Addresses

· Goodall, S. E. Presidential (1958–59): condensed version of 2

· Measurement and Control Section, Chairman, 1958–59: Summary of 21

· North Staffordshire Sub-Centre, Chairman, 1958–59: Article based on 280

· North-Western Electronics and Communications Group, Chairman, 1958–59: Article based on 139

· Radio and Telecommunication Section, Chairman, 1958–59: Summary of 23

· South Midland Centre, Chairman, 1958–59: Article based on 695

· Supply Section, Chairman, 1958–59: Summary of 22

· Utilization Section, Chairman, 1958–59: Summary of 20

Adequate Wiring for Electrical Installations in Buildings: Evidence by Panel on 708

Admiralty: Appointment of representative on Utilization Section Committee 668

Adventure of building, the 711

A.E.A.'s thermonuclear project 640

Aeronautics, College of

· Control engineering, postgraduate course in: Announcement of 486

· Governing Body: Nomination of representative on 413

Air Ministry: Appointment of representative on Utilization Section Committee 668

Aircraft Electrical Engineering, Committee on: Nomination of representatives on 398

Aircraft Electrical Equipment, Committee on Regulations for: Appointment on 554

Alberta, Oversea Representative for: Appointment of 554

Aldermaston, particle work at 425

All-electronic exchange 15, 728

Allanson, J. T., Layton, J. M., Jakeways, R. J., and Tustin, A. (*see* Tustin, A.)

Allcock, P. R. Presentation of Page Prize to 356

Amplifying techniques new: Lecture to Electronics and Communications Section by C. W. Oatley 336

Anderson, S. *Auxiliary equipment for fluorescent lighting* 212

Angell, B. C., Foot, J. B. L., Lucas, W. J., and Thompson, G. T. Award of an Electronics and Communications Section Premium 485

Announcements to members 47, 120, 190, 257, 331, 398, 411, 484, 554, 614, 668, 736

Annual Accounts for 1958 450

Annual Dinner: Report of 286

Annual General Meeting 257, 427

Annual Report for 1958–59 431

Appearance design in electrical engineering by T. B. Dunne 205

Applications of photoelectric cells by F. A. Benson 630

Appointments and nominations 47, 190, 258, 331, 398, 413, 484, 554, 668

Argentina Joint Group: Reports of activities 131, 563

Argentina, Oversea Representative for: Appointment of 484

Army: Appointment of representative on Electronics and Communications Section Committee 668

Army communication engineering 415

Ashmore, J. *Some recent developments in electrical insulation* 695

Association Suisse des Électriciens: Publication of handbook on electrical insulating materials 175

Atomic energy establishment (new) at Winfrith 511

Atomic spin, electrical uses of: Informal lecture to Measurement and Control Section by G. Phillips 339

Australia, Institution of Engineers: Reports of joint meetings with 406, 676

Australian Atomic Energy Commission

· Lucas Heights, news from 564

· Research grants: Announcement of 494

Automatic control in the Soviet Union by A. Tustin 521

Automatic Control, International Federation of

· Congress (1960): 48, 704, 737

· Executive Council 704

· First general assembly: Report of 704

· New constitution 704

Automatic control: Visit of experts to U.S.S.R. 373

Automatic controls in the U.S.S.R.: Report on 556

Automation, materials handling and by L. Landon Goodman 689

Automation: Thirtieth Faraday Lecture, by H. A. Thomas 147, 267, 268, 341, 342, 343, 407, 408

Auxiliary equipment for fluorescent lighting by S. Anderson 212

B

Banking, electronic aids to by **R. Feinberg** 139

Baricalla, G. Presented with Faraday Medal awarded to L. Emanueli 354

Barker, A. J. *Rural communication systems* 507

Barlow, H. E. M.

· *Long-distance transmission by waveguide* 24

· Nomination as an Ordinary Member of Council 257

Barton, F. S. Appointed Oversea Representative for Ontario 331

B.B.C. monographs: Publication of 600, 729

B.B.C. television and v.h.f. sound coverage 416

B.E.A.M.A.: Publication of 477

Bell, D. A. Award of Knight Fund grant 614

Benelux Section of Institute of Radio Engineers: Report of first meeting 661

Benevolent Fund, Incorporated

· Annual Report 629

· Donations to: Acknowledgment of 259

· Local Honorary Treasurers 63, 272, 498, 622, 743

Benson, F. A. *Applications of photoelectric cells* 630

Berkeley, nuclear research centre at 211

Bermuda, consumption of electricity in 564

Beurle, R. L. *Storage and manipulation of information in the brain* 75

Bigger and better power stations 361

Birmingham, City of, Education Department, Advisory Committee for Electrical Engineering: Nomination of representative on 331

Birmingham University, graduate course in information engineering: Announcement of 186

Blumlein–Browne–Willans Premium: Award to D. Gabor, P. R. Stuart and P. G. Kalman 486

B.N.E.C. (*see under* Nuclear)

Books (*see* Library accessions *and* Some recent books)

Boot, H. A. H., Foster, H., and Self, S. A. Award of an Electronics and Communications Section Premium 485

Booth, D. H., and Thornton, E. P. G. (*see* Thornton, E. P. G.)

Borissow, B. G. Appointed Oversea Representative for Argentina 484

Boyd, R. L. F. *Electronic instruments in space-research vehicles* 457

Boyse, C. O.

· Delivery of First Hunter Memorial Lecture 199, 341

· Nomination as an Ordinary Member of Council 257

· *P. V. Hunter—electrical engineering in our time* 501

Bradford Institute of Technology

· Advisory Committee on Electrical Engineering: Nomination of representative on 668

· Nuclear reactor technology, course in: Announcement of 192

Brailsford, F. *Modern ferromagnetic materials* 417

Brain, storage and manipulation of information in the by R. L. Beurle 75

Bray, W. J. *Public mobile radiotelephone service* 705

Bridging the Atlantic: Lecture to Electronics and Communications Section by A. H. Mumford 193

Bringing water and power to Kuwait by D. W. Smart 574

Bristol College of Technology, Engineering Advisory Committee: Nomination of representative on 485

Bristol University: Nomination of representative on Court of 47

British control experts visit U.S.S.R. 373

British Electrical and Allied Industries Research Association (*see* E.R.A.)
British Electrical and Allied Manufacturers' Association Incorporated (*see* B.E.A.M.A.)
British Electrical Development Association (*see* E.D.A.)
British Electrical Power Convention (Eleventh): Announcement of 121
British Guiana Joint Group: Report of inaugural meeting 563
British Internal Combustion Engine Research Association: Publication of handbook on torsional vibration 175
British Nuclear Energy Conference (*see* Nuclear)
British Productivity Council, Essay Prize Competition: Announcement of 49
British reactor equipment for Norway 707
British Standards Institution: I.E.E. representatives on Council and Committees of 47, 193, 258, 331, 398, 413, 484, 554, 668
British Standards: Publication of 318, 390, 600, 729
British Transport Commission: White Paper on modernization 730
Brunt, Sir David. Delivery of Fiftieth Kelvin Lecture 356
Building, Institution: Reconstruction of 134, 711
Building Research and Development, D.S.I.R. Standing Consultative Conference on: Nomination of representative on 668
Building, the adventure of 711
Buildings, provision of adequate electrical installations in, Symposium on 55, 398, 560
Buildings, Regulations for Electrical Equipment of (*see* Wiring Regulations)
Bulletin of the Sections 50, 122, 193, 260, 334, 400, 488, 558, 616, 672, 739
Buoyant cables 504
Burns, G. A., Fletcher, F., Chambers, C. H., and Gunning, P. F. (*see* Gunning, P. F.)
Busemann. F., and Casson, W. Award of Sebastian de Ferranti Premium 485
Butcher, P. N. Award of Kelvin Premium 485
Bye-laws of The Institution: Changes in 279, 641

C

Cable jointing 575
Cannock Chase Mining and Technical College: Nomination of representative on Engineering Advisory Committee 331
Capacitors for fluorescent lighting 218
Carrier telephone systems 507
Carter, F. C., and Williams, F. E. (*see* Williams, F. E.)
Casson, W., and Busemann, F. (*see* Busemann, F.)
Cattermole, K. W. Award of an Electronics and Communications Section Premium 485
C.C.I.R., work of, in Los Angeles 523
Central Film Library: List of new films 223
Centres, News from the 57, 128, 200, 265, 340, 407, 492, 561, 675, 741
Centrifugal stresses in turbo-alternator rotors by H. Fessler: Publication of 333
Ceylon, Oversea Representative for: Appointment of 190
Chambers, C. H., Gunning, P. F., Burns, G. A., and Fletcher, F. (*see* Gunning, P. F.)
Chandler, J. A. Award of a Graduate and Student Premium 486
Chapelcross nuclear power station 362
Cheaper subscriber connection 472
Cherry, E. C. Lecture entitled *On the conceivable future of telecommunications* 257
Chinese scientific literature 220
Chokes for fluorescent lighting 216
Christmas Holiday Lecture: Announcement of 669
C.I.E.: Report of 14th session of 526
C.I.G.R.É., British National Committee: Nomination of representative on 413
Circuit trends in domestic sound and broadcast receivers by F. A. Rodwell 567
C.I.S.P.R. Report of meeting at The Hague 9
City and Guilds of London Institute, Advisory Committee for Radio and Television Servicing: Nomination of representative on 413
Civilian studentships at Royal Military College of Science: Conditions of award 121, 670
Clark (Graham) Lecture (Fifth), by Sir Arnold Plant 363, 409
Clean Air, National Society for: Nomination of representative on Yorkshire Divisional Council 413
Clegg, J. E., and Thorne, T. G. Award of an Electronics and Communications Section Premium 485
Coal-fired power-station sites, investigation of suitable 204
Coal-fired power stations 361
Coastal-radio v.h.f. services 738
Coates, R. B. Letter of Commendation 486
Cock, C. M. Award of Swan Premium 485
Codes of Practice Council and Committees: Representatives on 71, 331, 668
Coles, H. E. Award of a Graduate and Student Premium 486
Commercial television programme presentation, engineering aspects of: Lecture to Electronics and Communications Section by T. C. Macnamara and B. Marsden 491
Committees of The Institution: Constitution
· Council, 1959–60 649, 678, 738
· Local Centre, 1959–60 681
· Miscellaneous, 1959–60 679
· Oversea Branches and Committees, 1959–60 685, 686
· Section, 1959–60 412, 678
Computers (business) in the U.S.A., some case-histories of by A. T. Starr 347
Concentration of advanced courses 426
Conferences
· Atomic energy, peaceful uses of (International): Publication of proceedings of 615
· Automatic boiler house: Announcement of 556
· Automatic control (National): Announcement of 268
· Dielectric devices (Birmingham University): Announcement of 332
· Eastern joint computer (1959): Invitation to authors to submit papers 399
· Electrical techniques in medicine and biology: Announcement of 333
· Electronic components (1959): Announcement of 48
· Electronic components (1960): Announcement of 671
· Electronics, 15th annual national: Announcement of 332
· Impact of nuclear development on electricity supply and on instrument techniques: Announcement of 555
· Information processing (International): Announcement of 122
· Instrumentation: Announcement of 332
· Ionization phenomena in gases (International): Announcement of 332
· Magnetism and magnetic materials: Announcement of 399
· Magnetism, some aspects of: Announcement of 121
· Materials handling (International): Announcement of 258
· Measurements (International): Publication of proceedings of 399
· Medical electronics (Second international): Announcement of 259
· Medical electronics (Third international): Announcement of 555, 736
· Military electronics (4th national): Announcement of 671
· National Society for Clean Air: Announcement of 121
Conferences (contd.)
· Network theory (Birmingham University): Announcement of 332
· Nuclear Energy, British (*see* Nuclear)
· SETS (1959): Report of 636
· World Power (*see* World)
Congresses
· Australian and New Zealand Association for the Advancement of Science: Announcement of 122
· Automatic control (First international): Announcement of 704
· Automatic Control, International Federation of: Announcement of 48
· Communication (7th international): Announcement of 487
· Interkama (Second international): Announcement of 332
· Microwave valves (International): Announcement of 332, 588
· Société Française des Électriciens: Announcement of 122
Contents of the current *Proceedings* 45, 119, 192, 240, 333, 397, 487, 557, 613, 667, 738
Control engineering, postgraduate course in: Announcement of 486
Control charts 702
Control gear 209
Control techniques (modern) on the railways: Report of discussion on 123
Conventions
· British Electrical Power (Tenth): Announcement of 121
· Electronics and nucleonics (1959): Announcement of 557
· Long-distance transmission by waveguide 24, 25, 195, 486
· Radio Engineers, Institute of (National): Announcement of 122
· Stereophonic sound recording, reproduction and broadcasting 49, 173, 670, 710
· Thermonuclear processes 226, 359, 669
· Transistors and associated semiconductor devices (International) 190, 273, 294, 491, 586
· Yorkshire Council of Further Education, Annual: Report of 426
Conveyors 690
Correspondence 30, 106, 168, 245, 315, 470, 532, 594, 657, 726
· Barlow, H. E. M. *Symbols for space co-ordinates* 533, 726
· Bentham, F. P. *Electric control of stage and television lighting* 657
· Brownlie, J. D. *Thermal electric oscillators* 532
· Bruce, C. E. R. *The velocity of propagation of electrical breakdown in a gas* 315
· Conning, A. M., Kayali, A. A., and Wright, G. T. *Space-charge-limited dielectric diodes* 595
· Feinberg, R. *Electronics and electrical engineering* 472
· Jeffrey, C. S. *Words words, words* 106
· Manwaring, D. B. *Load factor* 658
· Myers, B. R. *What is negative impedance?* 471
· Page, H. *Symbols for space co-ordinates* 657
· Robinson, O. D. *The junction transistor and its application* 30
· Robinson, O. D. *Load factor* 470
· Ryle, M., and Smith, F. G. *Radio-navigation system using earth satellites* 168
· Scroggie, M. G. *The junction transistor and its application* 315
· Sharp, P. E. M. *Electric control of stage and television lighting* 534
· Smee, J. F., and Edwards, F. S. *Effect of humidity on the dry flashover voltage of air-gaps and insulators* 594
· Unz, H. *The Heaviside papers found at Paignton in 1957* 470
· Warren, A. G. *What is negative impedance?* 316
· Wells, Robert. *The junction transistor and its application* 170

Correspondence (contd.)
· Westaway, H. R. *The junction transistor and its application* 106
· Williams, M. O. *What is negative impedance?* 169, 532
· Wilson, W. Proctor, Mayo, C. G., and Head, J. W. *What is negative impedance?* 595
· Wolfendale, E. *The junction transistor and its application* 106, 170, 245
Correspondence addressed to The Institution: Reference number on 332, 669
Corrosion of steel structures, proposed code of practice on prevention of: Nomination of representative on exploratory committee on 485
Costs of Post Office buildings reduced 500
Council of The Institution
· 1958–59: Constitution of 60, 269, 495
· 1959–60: Constitution of 411, 619, 677
Nominations for vacancies on 257
Cranes 692
Creighton, G. K., and Somerville, W. M. Award of a Graduate and Student Premium 486, 721
Crompton Premium: Award to P. McKearney, L. S. Drake and E. G. Mallalieu 485
Cryer, B. G. Letter of Commendation 486

D

Darke, J. A. Letter of Commendation 486
Darlington College of Further Education, Electrical Engineering Advisory Sub-Committee: Nomination of representative on 413
Data transmission, errors in: Lecture to Electronics and Communications, and Measurement and Control Sections by V. J. Terry and E. P. G. Wright 263
Davis, R. *40th anniversary of SEP* 524
D.C. amplifiers: Report of discussion on 260
Declaration on fair copying of scientific information (Royal Society) 48
Delhi College of Engineering and Technology, The 145
Delhi Engineering College Trust: Nomination of representative on Executive Committee of 398
Dell, R. *Programme machines on the Tube* 88
Denham, J. A. Award of a Graduate and Student Premium 486, 723
Dielectric materials—trends and prospects: Lecture to Electronics and Communications Section by C. G. Garton 194
Digital-computer techniques, specialist discussion meetings on: Report of 673
Digital computers, reliability of: Announcement of discussion meetings on 555
Dimensions of sound, the 710
Dinner, Annual: Report of 286
Dip.Tech. students doubled in a year 688
Direct dialling from the Continent 17
Discussions
· Presentation of, at meetings 120, 555
· Section (*see under* name of Section)
· Submission of written contributions to 120, 555
District Meetings (*see* Meetings)
Dounreay reactor critical 699
Dragon project 511, 577
Drake, L. S., Mallalieu, E. G., and McKearney, P. (*see* **McKearney, P.**)
Drakelow power stations 709
Driverless farm tractors 584
Drucquer, L. Nomination as an Ordinary Member of Council 257
D.S.I.R. reports: Publication of 477, 601
D.S.I.R. Standing Consultative Conference on Building Research and Development: Nomination of representative on 668
Dual-purpose electro-Diesel locomotives 624
Duddell Premium: Award to A. E. Karbowiak 485
Duddell Scholarship: Awards to G. P. Turner and G. Edmondson 614
Dunne, T. B. *Appearance design in electrical engineering* 205

E

Earth satellites, space research and 499
East Anglia, television stations in 553
East Anglian Regional Advisory Council for Further Education, Engineering Sub-Committees for Eastern and Western Areas: Nomination of representatives on 47
East Anglian Sub-Centre
· Annual Dinner-Dance: Report of 201
· Meetings: Report of 201
Eccles, Sir Josiah
· Proposal of vote of thanks to Sir David Brunt for Kelvin Lecture 358
· Proposal of vote of thanks to Mr. S. E. Goodall for Presidential Address 8
E.D.A.: Publications of 477
Edmondson, G. Award of Duddell Scholarship 614
Education and training 290
· Civilian studentships at Royal Military College of Science: Conditions of award 121, 670
· Control engineering, postgraduate course in (College of Aeronautics) 486
· Dip.Tech. students, numbers of 688
· Harwell Reactor School: Courses at 122, 670
· Higher technology, special courses in: Publication of bulletin of 119, 615
· Information engineering, graduate course in (Birmingham University): Announcement of 186
· Nuclear reactor technology, course in: Announcement of 192
· *Professional engineers,* booklet entitled: Publication of 517
· Radiological health and safety, special courses in: Announcement of 358
· Science, postgraduate courses in (Liverpool University): Announcement of 122
· Supply-industry university scholarships 517
· Three-year education programme 285
· *Training Regulations:* Publication of 709
Education Discussion Circle: Report of meeting 740
Elections and transfers 46, 118, 185, 256, 328, 396, 414, 483, 548, 610, 666, 732
Electric cables by S. E. Goodall 2
Electric locomotives of the French National Railways, performances of by F. Nouvion 625
Electric motors 208
Electric power in Europe 285
Electrical engineering, appearance design in by T. B. Dunne 205
Electrical engineering reviews
· *Auxiliary equipment for fluorescent lighting* 212
· *Circuit trends in domestic sound and broadcast receivers* 567
· *Materials handling and automation* 689
· *Modern ferromagnetic materials* 417
Electrical engineers and electronics by R. W. Palmer 280
Electrical engineers (professional), recruitment of, by G. S. C. Lucas 135
Electrical engineer's view of the home, the 708
Electrical equipment in new marshalling yard 743
Electrical floor-warming by P. Walsh 637
Electrical installations in buildings, provision of adequate, symposium on 55, 398, 560
Electrical insulation, some recent developments in by J. Ashmore 695
Electrical science, to promote the advancement of by R. C. Winton 586
Electrical uses of atomic spin: Measurement and Control Section informal lecture by G. Phillips 339
Electricity Council: Publication of booklet entitled *Power for the future* 175
Electricity from geothermal steam by E. L. E. Wheatcroft 83
Electricity in the home 708
Electrochimica acta: Publication of 601
Electroluminescence 635
Electronic aids to banking by R. Feinberg 139
Electronic control of machine tools: Report of discussion on 50
Electronic equipment in the process industries, the problem of maintenance of: Report of discussion on 488
Electronic instruments in space-research vehicles by R. L. F. Boyd 457
Electronic recorders for trains 671
Electronic telephone exchanges 15, 728
Electronic-valve industry, the application of statistical techniques to: Lecture to Electronics and Communications Section by E. G. Rowe 558
Electronics and Communications Section (*see also* Radio and Telecommunication Section)
· Chairman, 1959–60 (M. J. L. Pulling): Biographical note on 672
· Change from previous name 133, 291
· Committee, 1959–60:
Constitution of 412, 678
Representatives of Services on 668
· Day visit: report of 672
· Joint meeting with Measurement and Control Section: Report of 263
· Lectures
Commercial television, by T. C. Macnamara and B. Marsden 491
Dielectric materials, by C. G. Garton 194
Errors in data transmission, by V. J. Terry and E. P. G. Wright 263
New telephones for old, by F. E. William and F. C. Carter 400
Statistics controlled, by E. G. Rowe 558
Transatlantic communication, by A. H. Mumford 193
Ultra-sound image camera, by C. N. Smyth and J. F. Sayers 262
· Long-distance transmission by waveguide, convention on 24, 25, 195, 486
· Meetings: Reports of 193, 262, 336, 400, 558, 618, 739
· Premiums: Awards of 485
· Stereophonic sound recording, reproduction and broadcasting, convention on 49, 173
· Transistors and associated semiconductor devices, convention on 190, 273, 294, 491, 586
Electronics and National Certificates 426
Electronics in hospital equipment 424
Emanueli, Luigi. Award of Faraday Medal to 190, 354
Energy storage and load factor 203
Engineering aspects of commercial television programme presentation: Lecture to Electronics and Communications Section by T. C. Macnamara and B. Marsden 491
Engineering in an expanding economy: Fifth Graham Clark Lecture, by Sir Arnold Plant 363, 409
Engineering Institutions Examination Part I, Committee: Nomination of representatives on 47
Engineering institutions oversea: Reciprocal arrangements with 259, 614
Engineering Joint Examination Board: Nomination of representatives on 47
Engineering research summaries: Issue of 186
Engineering, women in: Report of discussion on 578
Entrance fees and annual subscriptions 525
Epps, R. M. Letter of Commendation 486
E.R.A. Council: Nomination of representative on 398
E.R.A. reports: Publication of 175, 318, 390, 477, 600, 729
Europe, electric power in 285
Examination (The Institution): List of successful candidates 187, 550
Exhibitions
· Hospital equipment and medical services (2nd international): Report of 424
· Radio Hobbies: Announcement of 557
· Radio Show 1959: Announcement of 49

F

Faraday Lecture, Thirtieth: *Automation* by H. A. Thomas 147, 267, 268, 341, 342, 343, 407, 408

Faraday Medal: Award to Luigi Emanueli 190, 354

Feinberg, R. *Electronic aids to banking* 139

Ferranti Scholarship: Award to R. Hawley 614

Ferranti (Sebastian de) Premium: Award to F. Busemann and W. Casson 485

Ferrites 423

Ferroelectrics: Report of discussion on 51

Ferromagnetic materials (modern) by F. Brailsford 417

Fessler, H. Publication of paper on *Centrifugal stresses in turbo-alternator rotors* 333

Fifty years of membership: List of members 120

Film on photoemission 694

Films available from Central Film Library 223

Fire Offices' Committee and D.S.I.R.: Publication of report of 601

First in safety 346

First international staff join 'Dragon' 577

First reactors for Scotland 362

Fleming (Ambrose) Premium: Award to G. D. Monteath 485

Fleming (Arthur) Scholarship: Award to M. J. Penny 614

Fletcher, F., Chambers, C. H., Gunning, P. F., and Burns, G. A. (*see* Gunning, P. F.)

Fluidized beds, improved control of 734

Fluorescent lighting, auxiliary equipment for by S. Anderson 212

Fluorometers 631

Fly in amber, the 73

Fones, D. R. Award of Salomons Scholarship 614

Foot, J. B. L., Lucas, W. J., Thompson, G. T., and Angell, B. C. (*see* Angell, B. C.)

Forewords 1, 73, 133, 203, 273, 345, 415, 499, 565, 623, 687

Forthcoming events 49, 114, 189, 254, 333, 397, 414, 477, 553, 613, 667, 735

40th anniversary of SEP by R. Davis 524

Foss, R. C. Award of Oliver Lodge Scholarship 614

Foster, A. P. Award of a Graduate and Student Premium 486, 653

Foster, H., Self, S. A., and Boot, H. A. H. (*see* Boot, H. A. H.)

Four pillars of The Institution: Utilization Section 18

French National Railways, performances of electric locomotives of the by F. Nouvion 625

Fry, D. W. Lecture on *Nuclear energy from controlled thermonuclear reaction* 198, 468

Fuel Efficiency and Power for Industry Exhibition, Institute of Fuel Organizing Committee: Nomination of representative on 668

Fusegear 206

G

Gabor, D., Stuart, P. R., and Kalman, P. G. Award of Blumlein–Browne–Willans Premium 486

γ-radiation, pilot-scale processing factory 566

Garton, C. G. Lecture entitled *Dielectric materials—trends and prospects* to Electronics and Communications Section 194

Geneva conference 1958 549

Geothermal steam, electricity from by E. L. E. Wheatcroft 83

Ghana Joint Group [formerly West African Joint Oversea Group (Ghana Branch)]: Report of inaugural meeting 564

Gibraltar Joint Group: Report of meeting 744

Gilford, C. L. S. Award of an Electronics and Communications Section Premium 485

Gill, D. M. Appointed Oversea Representative for Ceylon 190

Gillespie, E. F. F. Letter of Commendation 486

Ginger, L. A. M., and Webb, W. J. (*see* Webb, W. J.)

Godziński, Z. Award of Heaviside Premium 486

Goldup, T. E.
- Contribution to discussion on *Women in engineering* 579
- Proposal of toast of the guests at Annual Dinner 291
- Reply to vote of thanks for services as President 9

Golovin, I. N. Speaking at convention on thermonuclear processes 360

Goodall, S. E.
- Address of inauguration as President (1958–59): condensed version of 2
- Inauguration as President (1958–59) 6
- Institution Summer Meeting: Attendance at 518
- Measurement and Control Section Annual Dinner: Attendance at 50
- North Midland Centre Annual Dinner: Reply to toast of The Institution 130
- North-Western Centre Annual Dinner: Attendance at 409
- Northern Ireland Centre Annual Dinner and Dance: Reply to toast of our visitors 265
- *Proud of our part* 1
- Response to toast of The Institution at Annual Dinner 289
- Scottish Centre Dinner at Edinburgh: Reply to toast of The Institution 343
- Southern Centre Annual Dinner and Dance: Attendance at 342
- Supply Section Dinner-Dance: Attendance at 336
- Utilization Section Dinner-Dance: Attendance at 261
- Western Centre Annual Dinner-Dance: Attendance at 410

Goodman, L. Landon. *Materials handling and automation* 689

Government of The Institution 274

Graduate and Student Premiums: Awards of 486

Graduate and Student Sections: Officers 63, 272, 498, 622

Graduate Scholarship: Award of 614

Graduates' subscriptions: Reduction during period of National Service 331, 670

Green, George. *Essay on electricity and magnetism:* Publication of facsimile edition of 175

Grossett, W., Medhurst, R. G., and Hicks, E. M. (*see* Medhurst, R. G.)

Guernsey, subscriptions of members in: Income-tax relief on 399

Gunning, P. F., Burns, G. A., Fletcher, F., and Chambers, C. H. Award of a Supply Section Premium 485

H

Hailsham, The Rt. Hon. the Viscount: Opening Address at international convention on transistors and associated semiconductor devices 190

Hammond, P.
- Award of Non-Section Premium 486
- *The sagacious Mr. Cavendish* 582

Harle, J. A. Appointed Oversea Representative for Alberta, Canada 554

Harwell Reactor School: Courses at 122, 670

Hawley, R. Award of Ferranti Scholarship 614

Headquarters Committees, 1959–60 678

Heaviside papers: Article by H. J. Josephs 26

Heaviside Premium: Award to Z. Godzinski 486

Hicks, E. M., Grossett, W., and Medhurst, R. G. (*see* Medhurst, R. G.)

High-temperature gas-cooled reactors for nuclear power stations, investigation into use of 146

Higher technology, special courses in: Publication of bulletin of 119, 615

Hill, J. J. Award of Silvanus Thompson Premium 485

Hill, K. A. Award of David Hughes Scholarship 614

Hirst (Lord) Fund: Appointment of trustee of 258

Historical development of electrical engineering 280

History under the floorboards by **H. J. Josephs** (*see also* p. 45) 26

Hodgkin, A. L. Lecture entitled *The propagation of electrical signals along nerve fibres* to Measurement and Control Section 558

Hong Kong Joint Group: Report of meeting 564

Honorary Membership: Election of C. W. Speirs 190, 353

Honours and distinctions conferred on members 120, 484

Hopkinson (John) Premium: Award to F. C. Winfield, T. W. Wilcox and G. Lyon 485

Hore, R. A. Nomination as an Ordinary Member of Council 258

Hospital equipment, electronics in 424

Hughes (David) Scholarship: Award to K. A. Hill 614

Humphreys, O. W. Nomination as a Vice-President 257

Hunter, J. J. Award of a Graduate and Student Premium 486

Hunter Memorial Lecture (First), by C. O. Boyse 199, 341, 501

Hunter (P. V.)—electrical engineering in our time by C. O. Boyse 501

I

I.E.C. meetings in Madrid: Report of 534

Illuminating Engineering Society
- Light, lectures on: Announcement of 556
- Technical report: Publication of 477

Illuminating Engineering Society, 1909–1959 by John W. T. Walsh 221

I.M.E.A. Scholarship: Award to P. E. Secker 614

Improved control of fluidized beds 734

Income-tax relief on Institution subscriptions 258, 399, 556

Industrial non-destructive testing, meeting on: Announcement of 122

Information engineering, graduate course on (Birmingham University): Announcement of 186

Inquiring mind, the 409

Institut für Hochfrequenztechnik, Zürich: Publication of report of 601

Institute of Physics, Non-destructive testing group: Announcement of meeting of 122

Institute of Radio Engineers, Benelux Section: Report of first meeting of 661

Institution of Mechanical Engineers: Joint meeting with I.E.E. 198

Institution, The
- Annual Accounts for 1958 450
- Annual Dinner: Report of 286
- Annual General Meeting 257, 427
- Annual Report for 1958–59 431
- Building: Reconstruction of 134, 438, 711
- Bye-laws: Changes in 279, 641
- Council of (*see* Council)
- Examination (*see* Examination)
- Facilities of the Library 224
- *Four pillars of The Institution: The Utilization Section* 18
- Gift to 614
- Government of 274
- *Institution, The, in Yorkshire* 518
- Library: Facilities of 224
- Officers of (*see* Officers)
- Representatives of, on other bodies 64 (*see also* Appointments and nominations)
- Special General Meetings 274, 279, 487
- Summer Meeting (1959) 59, 191, 284, 518
- Summer Meeting (1960) 675, 707

Institution tie: Prices of 191, 736

Insulated wire, radioisotope test for 671

Insulating materials (electrical): Publication of handbook on 175

International Commission on Illumination: Report of 14th session 526

International Geophysical Year, 1957–58: Fiftieth Kelvin Lecture, by Sir David Brunt 356

International Special Committee on Radio Interference (*see* C.I.S.P.R.)
Investigating coal-fired power-station sites 204
Irrigation and drainage, International Commission on: Nomination of representative on British National Committee 258

J

Jackson, Sir Willis
· Mersey and North Wales Centre Annual Dinner: Reply to toast of The Institution 742
· Nomination as President 257
· Opening of discussion on *Women in engineering* 578
· Seconding of vote of thanks to retiring President (1957–58), Mr. T. E. Goldup 9
Jakeways, R. J., Tustin, A., Allanson, J. T., and Layton, J. M. (*see* Tustin, A.)
Jesty, L. C. Award of an Electronics and Communications Section Premium 485
Josephs, H. J. *History under the floorboards* (*see also* p. 45) 26

K

Kalman, P. G., Gabor, D., and Stuart, P. R. (*see* Gabor, D.)
Kandiah, K. Opening of Measurement and Control Section discussion on *D.C. amplifiers* 260
Karbowiak, A. E. Award of Duddell Premium 485
Kelvin Lecture (Fiftieth), by Sir David Brunt 356
Kelvin Premium: Award to P. N. Butcher 485
Kendon, M. H. Letter of Commendation 486
Kerruish, N., and Walker, J. H. (*see* Walker, J. H.)
Kilmuir, The Rt. Hon. the Viscount. Proposal of toast of The Institution at Annual Dinner 287
Kipping, Sir Norman. Response to toast of the guests at Annual Dinner 293
Knight Fund: Award of grant to D. A. Bell 614
Kuwait, bringing water and power to by D. W. Smart 574

L

Labour and National Service, Ministry of
· Engineering Advisory Panel: Nomination of representatives on 554
· Panel of Advisers at Leeds: Nomination of representative on 190
· Utilization Section Committee: Appointment of representative on 668
Lancashire and Cheshire Institutes, Union of: Nomination of representative on Engineering Advisory Committee 668
Lane, J. A. Award of an Electronics and Communications Section Premium 485
Larkinson, R. B. Award of a Graduate and Student Premium 486
Lawrence, J. A. *Trends in Post Office telephone-exchange equipment* 10
Lawrenson, P. J. Letter of Commendation 486
Lawton, F. L. Appointed Oversea Representative for Quebec 331
Layton, J. M., Jakeways, R. J., Tustin, A., and Allanson, J. T. (*see* Tustin, A.)
Lectures
· *Application of statistical techniques to the electronic-valve industry* by E. G. Rowe 558
· *Bridging the Atlantic* by A. H. Mumford 193
· Christmas Holiday: Announcement of 669, 738
· *Commercial television* by T. C. Macnamara and B. Marsden 491
· *Dielectric materials* by C. G. Garton 194
· *Electrical uses of atomic spin* by G. Phillips 339
· *Errors in data transmission* by V. J. Terry and E. P. G. Wright 263
· Faraday (Thirtieth), by H. A. Thomas 147, 267, 268, 341, 342, 343, 407, 408
· Graham Clark (Fifth), by Sir Arnold Plant 363, 409
Lectures (contd.)
· Hunter Memorial (First), by C. O. Boyse 199, 341, 501
· Kelvin (Fiftieth), by Sir David Brunt 356
· Light (Illuminating Engineering Society): Announcement of 556
· *Lighting and architecture* by J. M. Waldram 488
· Measurement and Control Section, Annual, by A. L. Hodgkin 558
· Measurement and Control Section, Annual, by A. T. Starr: Article based on 347
· *New amplifying techniques* by C. W. Oatley 336
· *New Post Office 700-type telephone* by F. E. Williams and F. C. Carter 400
· *Nuclear energy from controlled thermonuclear reaction* by D. W. Fry 198, 468
· *On the conceivable future of telecommunications* by E. C. Cherry 257
· *Probability and statistics in engineering problems* by M. D. McCarthy 700
· *Storage and manipulation of information in the brain* by R. L. Beurle 75
· Supply Section, Annual, by P. J. Squire 261, 617
· *Transmission of news film over the transatlantic cable* by C. B. B. Wood and I. J. Shelley: Announcement of 463
· *Ultra-sound image camera* by C. N. Smyth and J. F. Sayers 262
Lee, E. W. Award of a Measurement and Control Section Premium 485
Leete, E. Nomination as Honorary Treasurer 257
Lending Library catalogue: Publication of new edition 614
Letters of Commendation (Graduate and Student Premiums) 486
Library accessions 115, 181, 255, 329, 394, 482, 545, 608, 665, 733
Library of The Institution, facilities of the 224
Library, periodicals taken by the 183
Light Railway Transport League: Publication of book by B. J. Prigmore 730
Lighting and architecture: Report of lecture to Utilization Section by J. M. Waldram 488
Lightning protection of buildings 524
Liverpool University, postgraduate courses in science: Announcement of 122
Lloyd's Register of Shipping: Nomination of representative on technical committee of 485
Load factor and energy storage 203
Local Centres and Sub-Centres
· Benevolent Fund, Local Honorary Treasurers 63, 272, 498, 622, 743
· Committees, 1959–60: Constitution of 681
· Meetings: Reports of 57, 128, 200, 265, 340, 407, 492, 561, 675, 741
· Officers 61, 270, 496, 620
Loch Awe, pumped storage at 204
Loch Shin, power from 94
Lodge, Oliver Joseph: Portrait of 121
Lodge (Oliver) Scholarship: Award to R. C. Foss 614
London and Home Counties Regional Advisory Council for Technological Education: Announcement of courses in higher technology 119, 615
London Graduate and Student Section: Joint meeting with Utilization Section 125, 334
London report 56, 126, 198, 264, 405, 675, 740
London Underground railways, automatic routing on 88
Long-distance transmission by waveguide by H. E. M. Barlow 24
Long-distance transmission by waveguide, convention on:
· Programme of 25
· Publication of papers and discussions 486
· Report of 195
Loughborough College of Technology Advisory Committee on Industrial Engineering: Nomination of representative on 398
Low-Temperature Group of Physical Society: Subscriptions to 332
Lucas, G. S. C.
· Nomination as a Vice-President 257
· *Recruitment of professional electrical engineers* 135
· Scottish Centre Dinner-Dance: Reply to toast of The Institution 58
· West Wales (Swansea) Sub-Centre Annual Dinner-Dance: Reply to toast of The Institution 268
Lucas Heights, news from 564
Lucas, W. J., Thompson, G. T., Angell, B. C., and Foot, J. B. L. (*see* Angell, B. C.)
Lyon, G., Winfield, F. C., and Wilcox, T. W. (*see* Winfield, F. C.)

M

McCarthy, M. D. *Statistics and engineering* 700
McCartney, W. A. Award of a Graduate and Student Premium 486
Macdiarmid, I. F., and Phillips, B. Award of an Electronics and Communications Section Premium 485
MacGregor-Morris, J. T., letters of: Gift to The Institution 614
Machine noise, colloquium on: Announcement of 583
Machine tools, electronic control of: Report of discussion on 50
Machine tools, numerical control of by O. S. Puckle 512
McKearney, P., Drake, L. S., and Mallalieu, E. G. Award of Crompton Premium 485
MacKellar, A. St. John. Letter of Commendation 486
MacLaren, Sir Hamish. Attendance at Annual Dinner of North Staffordshire Sub-Centre 340
MacLennan, D. K. Letter of Commendation 486
Macnamara, T. C., and Marsden, B. Lecture entitled *Engineering aspects of commercial television programme presentation* to Electronics and Communications Section 491
Magic of a name, the 133
Magnetic-tape files 351
Malaya and Singapore, Deputy Oversea Representative for: Appointment of 413
Mallalieu, E. G., McKearney, P., and Drake, L. S. (*see* McKearney, P.)
Manchester College of Science and Technology: Nomination of representative on Court of Governors 668
Marryat, R. A. Address as Chairman of Utilization Section (1958–59) 20
Marsden, B., and Macnamara, T. C. (*see* Macnamara, T. C.)
Marshall, D. Award of a Graduate and Student Premium 486
Materials handling and automation by L. Landon Goodman 689
Mather Premium: Award to G. H. Rayner 485
Mayo, C. G., and Page, H. Award of an Electronics and Communications Section Premium 485
Measurement and Control Section
· Address by Chairman, 1958–59: Summary of 21
· Annual Dinner: Report of 50
· Annual Lecture, 1957–58, by A. T. Starr: Article based on 347
· Annual Lecture, 1958–59, by A. L. Hodgkin 558
· Committee, 1959–60:
Constitution of 412, 678
National Physical Laboratory representative on 668
· Digital computer-techniques, specialist discussion meetings on: Report of 673
· Discussions:
D.C. amplifiers 260
Electronic control of machine tools 50
Ferroelectrics 51
Instrument maintenance 488
Modern control techniques on the railways 123
· Joint meeting with Electronics and Communications Section: Report of 263
· Joint meeting with Supply Section: Report of 123

Measurement and Control Section (contd.)
· Joint meeting with Utilization Section: Report of 197
· Lectures:
Electrical uses of atomic spin, by G. Phillips 339
Errors in data transmission, by V. J. Terry and E. P. G. Wright 263
· Meetings: Reports of 51, 260, 338, 404, 488
· Premiums: Awards of 485
· Reliability of digital computers, discussions on: Announcement of 555
· Summer visit: Report of 618
Mechanical Engineering Research Laboratory
· Engineering research summaries: Issue of 186
· New name for 361
Mechanical engineering science, Journal of: Announcement of publication of 390
Mechanical Engineers, Institution of: Joint meeting with I.E.E. 198
Mechanization of thought processes: Report of symposium on 31
Medhurst, R. G., Hicks, E. M., and Grossett, W. Award of an Electronics and Communications Section Premium 485
Medical electronics, third international conference on: Announcement of 555, 736
Meetings
· Annual General 257, 427
· District:
Announcements of 46, 117, 256, 557, 613, 666, 735
Reports of 56, 126, 131, 199, 405, 675, 741, 742, 743
· Joint meeting with Institution of Mechanical Engineers: Report of 198
· Joint meetings with British Nuclear Energy Conference: Reports of 196, 198, 260
· Local Centre: Reports of 57, 128, 200, 265, 340, 407, 492, 561, 675, 741
· London: Reports of 7, 50, 123, 127, 147, 193, 198, 260, 264, 334, 353, 363, 400, 405, 617, 739, 740
· Ordinary: Reports of 7, 127, 198, 262, 264, 405
· Section (*see under* names of Sections)
· Special General 274, 279, 414, 487, 645
· Summer (1959) 59, 191, 284, 518
· Summer (1960): Announcement of 675, 707
Melling, C. T.
· North-Western Centre: Attendance at meeting of 408
· Seconding of vote of thanks to Sir David Brunt for Kelvin Lecture 358
Members, announcements to 47, 120, 190, 257, 331, 398, 411, 484, 554, 614, 668, 736
Members
· Correspondence from: Use of reference number on 332, 669
· Guests of: Introduction at meetings 555
· Honours and distinctions conferred on 120, 484
· Register of: Changes of address 331, 670
· Subscriptions:
Income-tax relief on 258, 399
Retired members: Revision of Council's rule 668
Waiving of 398
· Travelling to and from United Kingdom: Letter from Secretary 48, 486
Membership
· Fifty years of: List of members 120
· Honorary (*see* Honorary)
Meredith, R. J. Award of a Graduate and Student Premium 486
Mersey and North Wales Centre
· Annual Dinner (1958): Report of 57
· Annual Dinner (1959): Report of 741
· Annual Dinner-Dance: Report of 341
· Annual General Meeting: Report of 342
· District Meetings: Reports of 129, 341
· Golf tournament: Report of 561
· Meetings: Reports of 129, 341, 741
· Summer Meeting: Report of 561
Middle East Joint Group: Reports of activities 131, 343, 494
Millington, G. Address as Chairman of Radio and Telecommunication Section (1958–59) 23
Milne, G. R. Appointed Oversea Representative for New Zealand 668
Ministry of Labour and National Service
· Engineering Advisory Panel: Nomination of representatives on 554
· Panel of Advisers at Leeds: Nomination of representative on 190
· Utilization Section Committee: Appointment of representative on 668
Model Forms of General Conditions of Contract (Electrical), Committee on: Appointments on 484, 554
Model Forms of General Conditions of Contract, Joint Committee on: Appointments on 413, 484, 554
Modern ferromagnetic materials by F. Brailsford 417
Modernization, White Paper on railway: Publication of 730
Molecular and atomic motions: Announcement of meeting on 121
Monographs published individually this month 45, 110, 174, 245, 319, 386, 413, 476, 534, 600, 660, 728
Monteath, G. D. Award of Ambrose Fleming Premium 485
More calls on submarine telephone cables 549
Mumford, A. H.
· Lecture entitled *Bridging the Atlantic* to Electronics and Communications Section: Report of 193
· Mersey and North Wales Centre Annual Dinner: Response to toast of The Institution 57
· North Staffordshire Sub-Centre: Attendance at meeting of 492
· Seconding of vote of thanks to S. E. Goodall for Presidential Address 8
· Sheffield Sub-Centre: Attendance at meeting of 202
· Southern Centre Dinner-Dance at Brighton: Attendance at 409

N

National Academy of Sciences: Publications of 390
National Bureau of Standards: Publications of 319, 601
National Certificates, electronics and 426
National Certificates (England and Wales), Joint Committee for: Nomination of representatives on 47, 413
National Certificates (Northern Ireland), Joint Committee for: Nomination of representatives on 47
National Certificates (Scotland), Joint Committee for: Nomination of representatives on 47
National Engineering Laboratory 361
National Lending Library for Science and Technology 45, 220, 688
National Physical Laboratory: Appointment of representative on Measurement and Control Section Committee 668
National Service: Reduction of subscriptions to Graduates and Students on 331
National Society for Clean Air, Yorkshire Divisional Council: Nomination of representatives on 413
Naval officers, new titles for 361
Nelson, H. G. Nomination as an Ordinary Member of Council 258
Nerve fibres, the propagation of electrical signals along: Lecture to Measurement and Control Section by A. L. Hodgkin 558
New television stations 553
New Zealand, Oversea Representative for: Appointment of 668
News from abroad 131, 268, 343, 406 494, 563, 676, 744
News from the Centres 57, 128, 200, 265, 340, 407, 492, 561, 675, 741
Nickel-iron alloys 420
Nile, blowing up the source of the 564
Nimrod proton synchrotron 426
Nominations and appointments 47, 190, 258, 331, 398, 413, 484, 554, 668
Non-Section Premium: Award of 486
North-Eastern Centre: Report of meetings 128
North-Eastern Radio and Measurement Group: Report of meeting 128
North Lincolnshire District: Report of meetings 340, 743
North Midland Centre
· Annual Dinner: Report of 129
· Annual Dinner-Dance: Report of 408
· Annual General Meeting: Report of 407
· Annual golf match: Report of 742
· District Meetings: Reports of 131, 742
· Institution Summer Meeting 191, 284, 518
· Meetings: Reports of 130, 266, 340, 407, 742
North Midland Utilization Group: Reports of meetings 131, 266, 408
North Staffordshire Graduate and Student Section: Report of meeting 493
North Staffordshire Sub-Centre
· Address by Chairman, 1958–59: Article based on 280
· Annual Dance: Report of 201
· Annual Dinner: Report of 340
· Annual General Meeting: Report of 562
· Committee: New appointments on 202
· District Meetings: Reports of 340
· Meetings: Reports of 58, 201, 340, 492, 562
· Summer Meeting: Report of 563
North-Western Centre
· Annual Dinner: Report of 408
· Christmas Holiday Lecture: Report of 408
· Meetings: Report of 408
· University Lecture, 14th annual: Report of 408
North-Western Electronics and Communications Group: Address by Chairman, 1958–59, article based on 139
North-Western Supply Group: Report of meetings 559
North-Western Utilization Group
· Annual Dinner-Dance: Report of 267
· Meetings: Report of 408
Northern Ireland Centre
· Annual Dinner and Dance: Report of 265
· Meetings: Reports of 128, 266
Norway, British reactor equipment for 707
Nottingham University: Nomination of representative on Court of 258
Nouvion, F. *Performances of electric locomotives of the French National Railways* 625
Nuclear development, impact of, on electricity supply and on instrument techniques: Announcement of convention on 555
Nuclear Energy Conference, British
· Functions of 191, 549, 735
· Joint meetings with I.E.E.: Reports of 196, 198, 260
· *Journal* of 191, 549, 615, 735
· Meetings: Announcements of 43, 114, 189, 256, 487, 549, 615, 667, 735
Nuclear energy from controlled thermonuclear reaction: Lecture by D. W. Fry 198, 468
Nuclear reactor technology, course in: Announcement of 192
Nuclear research centre at Berkeley 211
Numerical control of machine tools by O. S. Puckle 512

O

Oatley, C. W. Report of lecture entitled *New amplifying techniques* to Electronics and Communications Section 336
Obituary 43, 107, 171, 246, 316, 387, 473, 535, 596, 658, 725
· Adams, C. A. 535
· Allan, R. 473
· Andrews, A. E. D. 171

Obituary (contd.)
- Angwin, Sir A. S. 387
- Asdell, J. H. 107
- Atkinson, J. 316
- Barker, E. A. 107
- Barney, L. W. 535
- Bear, M. M. 107
- Bird, W. 535
- Bishop, D. H. 658
- Blades, H. W. 43
- Blandford, A. R. 535
- Boyce, J. 388
- Bradford, G. 725
- Bramwell, F. H. 43
- Brazell, C. H. 535
- Brooks, A. 171
- Broughton, H. H. 108
- Burgess, W. A. A. 596
- Carey-Brown, J. 596
- Carr, L. H. A. 658
- Cooper, J. S. St. G. 536
- Cosgrove, C. W. 246
- Crosbie, C. W. 536
- Dalton, Sir J. C. J. 536
- Davies, A. W. 246
- Dawson, B. 597
- Dinham-Peren, A. E. H. 473
- Dover, A. T. 659
- Eaton, R. N. 246
- Eckersley T. L. 536
- Emanueli, L. 473
- Erlebach, W. A. 316
- Ewing, S. E. T. 108
- Feltham, J. B. 246
- Field, J. F. 108
- Fraser, H. G. 473
- Fraser, W. 171
- Garner, R. H. 388
- Gee, W. C. 246
- Grant, J. W. 247
- Gray, A. S. 597
- Green, J. D. 171
- Grinsted, W. H. 725
- Grover, C. A. 108
- Gueilikman, M. 109
- Harber, F. O. 725
- Hedley, J. 474
- Herbert, A. S. 474
- Heurtley, E. S. 247
- Higham, J. B. J. 172
- Howard, H. L. 388
- Howgrave-Graham, R. P. 474
- Ince, J. O. 388
- Instrall, R. C. 597
- Jackson, F. T. 659
- Jagger, H. H. 109
- Jephcott, E. L. R. 597
- Johnson, E. M. 172
- Jones, R. S. 659
- Kirkwood, I. W. A. 474
- Larke, Sir W. J. 598
- Lucas, J. G. 537
- McFarlane, W. 475
- MacGregor-Morris, J. T. 475
- McKinney, J. A. 389
- Mallinson, A. B. 537
- Marsingall-Thomas, C. 537
- Mavor, J. B. 389
- Mersh, C. M. B. 659
- Morris, J. M. 317
- Mulleneux, H. J. 389
- Oswald, H. 247
- Paterson, H. 389
- Payn, H. 475
- Peck, H. G. S. 598
- Penney, A. E. 247
- Picken, W. J. 317
- Pike, M. A. 109
- Powell, P. H. 389
- Purrett, J. 725
- Ram, W. 475
- Record, J. W. 726
- Robson, O. L. 537
- Ross, William 537
- Seshasayee, V. 317
- Shearing, G. 172
- Sherratt, T. 537
- Sillar, H. M. 538
- Sims, J. W. 726
- Smith, H. S. 248
- Smith, J. F. 538
- Somayajulu, B. R. 109
- Soutar, G. R. C. 317
- Steele, E. W. 173
- Steele, W. H. 173
- Sundaram, Gangadhara 248
- Swangren, E. G. F. 538
- Tattersall, H. W. 659
- Thorpe, W. B. 598
- Unbehaun, A. C. 538
- Waters, J. H. 538
- Watson, Sir D. 726
- Weymouth, G. A. P. 726
- Wilson, J. L. 598

O.E.E.C. reports: Publication of 390, 729

Officers of The Institution 60, 269, 495, 619, 677

Ontario, Oversea Representative for: Appointment of 331

Ordinary Meetings (*see* Meetings)

Orrin hydro-electric station 517

Other bodies, representatives of The Institution on 64 (*see also* Appointments and nominations)

Oversea Activities Committee: Appointments on 484

Oversea Attendance Register 59, 132, 202, 259, 344, 406, 494, 564, 615, 744

Oversea Branches, Committees, and Joint Groups
- Activities of 131, 343, 406, 494, 563
- Constitution of 685, 686
- Officers 62, 271, 272, 497, 498, 621, 622

Oversea engineering institutions: Reciprocal arrangements with 259, 614

Oversea members: Invitation to submit communications 59, 555

Oversea Representatives of the Council 47, 62, 190, 271, 331, 413, 484 497, 554, 621, 668, 685

Oxford District Meetings: Reports of 56, 128, 199, 405, 675, 741

P

Page, H., and Mayo, C. G. (*see* Mayo, C. G.)

Page Prize: Presentation to P. R. Allcock 356

Palmer, R. W. *Electrical engineers and electronics* 280

Papers published individually this month 44, 110, 174, 319, 386, 413, 476, 599, 660, 727
(*see also Proceedings* papers and monographs)

Particle work at Aldermaston 425

Patents delegation to Russia 709

Penny, M. J. Award of Arthur Fleming Scholarship 614

Performances of electric locomotives of the French National Railways by F. Nouvion 625

Periodicals taken by the Library 183

Permanent-magnet materials 421, 716

Phillips, B., and Macdiarmid, I. F. (*see* Macdiarmid, I. F.)

Phillips, G. Report of lecture entitled *Electrical uses of atomic spin* to Measurement and Control Section 339

Photoelectric cells, applications of by F. A. Benson 630

Photoemission, film on 694

Photometry 630

Photoprint service, Science Museum Library 49

Physical Society, Low-Temperature Group: Subscriptions to 332

Physics research laboratories, design of: Publication of report of symposium on 319

Pilot-scale γ-radiation processing factory 566

Plant, Sir Arnold. Delivery of Fifth Graham Clark Lecture 363, 409

Plastics, progress in 345

Popularity of s.t.d. 472

Portrait of President 1958–59 *frontispiece*

Portraits of pioneers of communication engineering 121

Post Office buildings, reduction in costs of 500

Post Office exchange apparatus 472

Post Office 700-type telephone, the new: Lecture to Electronics and Communications Section by F. E. Williams and F. C. Carter 400

Post Office telephone-exchange equipment, trends in by J. A. Lawrence 10

Pound and yard, standardization of 74

Power Conference, World (*see* World)

Power from Loch Shin 94

Power stations, bigger and better 361

Practical papers in the *Proceedings*: Submission of 399, 736

Premiums: Award of 485

Preservation of Rural Wales, Council for the: Nomination of representative on General Committee 398

President (1958–59) (*see* Goodall, S. E.)

President (1959–60) (*see* Jackson, Sir Willis)

Printed wiring 571

Proceedings, the
- Contents of current issues of (*see* Contents)
- Practical papers in: Submission of 399, 736
- Review of (*see* Review)
- Supplements to: Publication of 486, 669, 670

***Proceedings* papers and monographs**
- Adamson, C., and Talkhan, E. A. *Application of transistors to phase-comparison carrier protection* 105, 119
- Aldred, A. S., and Shackshaft, G. *Frequency-response method for the predetermination of synchronous-machine stability* 413, 476
- Allan, C. L. C. *Water-turbine-driven induction generators* 728
- Alston, L. L. *Impulse initiation of arc discharges* 100, 125, 248

***Proceedings* papers and monographs** (contd.)
- Alston, L. L., and Bruce, F. M. *Investigations of power-follow-current phenomena using a synthetic power source* 100, 125, 248
- Anderson, H. H., and Crawford, W. G. *Submersible pumping plant* 599
- Atkinson, M. P., Bane, W. T., and Barber, D. L. A. *A design for an automatic graph plotter* 306, 333
- Bachmann, A. E. *Transistor active filters using twin-T rejection networks* 167, 192
- Bain, W. C., and Shearman, E. D. R. *Observations on the U.S.S.R. earth satellites and the study of radio-wave propagation* 313, 333
- Barlow, H. E. M. *The power radiated by a surface wave circulating around a cylindrical surface* 167, 192
- Barlow, H. E. M. *Propagation around bends in waveguides* 192
- Barnes, R. C. M., and Stephen, J. H. *Operating experience with a transistor digital computer* 33, 51, 192
- Barron, D. A. *Subscriber trunk dialling* 236, 264, 487
- Bassett, H. G., Thomson, D., and Greenaway, P. E. *The application of junction transistors to audio-frequency telephone-line amplifiers* 194, 230, 333
- Beck, A. H. W. *High-current-density thermionic emitters: a survey* 307, 336, 487
- Benson, F. A., and Chalmers, P. M. *Effects of argon content on characteristics of neon-argon glow-discharge reference tubes* 192, 400
- Binns, J. W., and Outram, W. J. *Electrification of U.K.A.E.A. factories* 40, 54, 248
- Bishop, D. O., and Brosan, G. S. *Electromagnetic variable-ratio torque convertor* 174, 377, 404, 738
- Brosan, G. S., and Bishop, D. O. *Optimum ratio of copper losses and iron losses for a transformer with variable load* 661
- Brown, J., and Sharma, K. P. *The launching of radial cylindrical surface waves by a circumferential slot* 166, 192
- Brown, J. E., and Jha, C. S. *The starting of a 3-phase induction motor connected to a single-phase supply system* 243, 248
- Brunt, Sir David *The International Geophysical Year 1957–58* 613
- Bryant, P. R. *Order of complexity of electrical networks* 387, 557
- Bryant, P. R. *Topological investigation of network determinants* 192
- Buckley, G. W., and Gunson, J. *Theory and behaviour of helix structures for high-power pulsed travelling-wave tube* 44, 233, 263, 613
- Butson, P. C., and Thompson, G. T. *The effect of flanges on the radiation patterns of waveguide and sectoral horns* 244, 487
- Carne, A., and Brown, J. *Theory of reflections from the rodded-type artificial dielectric* 38, 53, 192
- Carpenter, C. J. *Surface-integral methods of calculating forces on magnetized iron parts* 413, 476
- Carter, G. W., and Loh, S. C. *Calculation of the electric field in a sphere-gap by means of dipolar co-ordinates* 45, 192
- Chard, F. de la Court *A note on the diagrammatic estimation of phase-sequence components* 244, 248
- Child, M. R., and Sargent, D. J. *A method for the accurate measurement of mutual conductance of thermionic valves* 313, 333
- Clarricoats, P. J. B. *The gain of travelling-wave ferromagnetic amplifiers* 319, 557, 714
- Clarricoats, P. J. B. *Perturbation method for circular waveguides containing ferrites* 313, 333
- Cock, C. M. *The Deltic locomotive* 155, 198, 248
- Collings, E. W. *Filament noise source for 3Gc/s* 45, 192

***Proceedings* papers and monographs** (contd.)

- Corbyn, D. B., and Potter, N. L. *Characteristics and protection of semiconductor rectifiers* 660
- Cotton, S. J. *Comparison of transient response of amplitude-modulated and frequency-modulated signals* 192
- Craven, G., and Knight, V. H. *The design and testing of integrally constructed waveguide assemblies* 314, 333
- Crowley-Milling, M. C. *Application of irradiation in industry* 599
- Cullen, A. L. *Theory of the travelling-wave parametric amplifier* 476, 713
- Curnow, H. J., and Mathias, L. E. S. *Multicavity klystron with double-tuned output circuit* 44, 229, 263, 613
- Cutteridge, O. P. D. *Some tests for the number of positive zeros and for the numbers of real and complex zeros of a real polynomial* 728
- Cutteridge, O. P. D. *Stability criteria for linear systems* 110, 557
- Davies, I. F., and Dunthorne, D. *Application of power transistors to the operation of gas-discharge lamps from d.c. supplies* 727
- Davies, M. *Relationship between weather and electricity demand* 192
- Davies, M., Moran, F., and Bird, J. I. *Power/frequency characteristics of the British Grid system* 102, 123, 248
- Davis J. H. *Silicone electrical insulation* 152, 197, 397
- Deeley, E. M. *Quadratic interpolation in tapped-potentiometer function generators* 45, 192
- Deshpande, M. V., and Subrahmanyan, T. R. *A new method of determining rotor leakage reactance and resistance of a three-phase induction motor* 105, 119
- Dewison, D. A. *Electrical supplies to power-station auxiliaries* 464, 490, 738
- Einhorn, H. D. *Discrimination between h.r.c. fuses and miniature circuit-breakers* 600
- Eldridge, D. *A new high-speed digital technique for computer use* 32, 51, 192
- Essen, L., Hope, E. G., and Parry, J. V. L. *Circuits employed in the N.P.L. caesium standard* 164, 192
- Essen, L., Parry, J. V. L., and Steele, J. McA. *Frequency variations of quartz oscillators and the earth's rotation in terms of the N.P.L. caesium standard* 413, 476
- Fay, F. S., Thomas, J. A., Legg, D., and Morton, J. S. *Development of high-voltage air-break circuit-breakers with insulated-steel-plate arc chutes* 311, 335, 613
- Feinberg, R. *Effect of temperature on persistence of long-persistence cathode-ray-tube screens* 192
- Forrest, J. S., Lambeth, P. J., and Oakeshott, D. F. *Research on the performance of high-voltage insulators in polluted atmospheres* 600
- Forte, S. S. *New synthesis procedure for two-terminal-pair networks using symmetrical lattice structure* 45, 192
- Fry, D. W. *A review of work towards nuclear energy from controlled thermonuclear reaction* 468, 487
- Gayford, M. L. *High-quality microphones* 110, 589, 618, 667
- Gilford, C. L. S. *The acoustic design of talks studios and listening-rooms* 149, 193, 333
- Giordani, F. *The objective for Euratom* 119
- Gjessing, Dag T. *Simple investigation of cross-modulation distortion arising from pulling effect in a frequency-modulated klystron* 44, 234, 263, 613
- Gleghorn, J. *Analogue electronic multiplier using transistors as square-wave modulators* 386
- Glucharoff, T., and Gilbert, C. P. *Use of silicon diodes in d.c. modulators and their applications to drift correctors for computing amplifiers* 600

***Proceedings* papers and monographs** (contd.)

- Godziński, Z. *Comparison of Millington's method and the equivalent-numerical-distance method with the theory of ground-wave propagation over an inhomogeneous earth* 192
- Golds, L. B. S. *Influence of consumers' load/consumption characteristics on metering practice* 110, 302, 338, 613
- Goodall, E. G. A. *Hemi-isotropic radiators for the S- or X-band* 314, 333
- Gould, J. E. *Progress in permanent-magnet materials* 716, 738
- Gouriet, G. G., and Newell, G. F. *Quadrature network for generating vestigial-sideband signals* 599
- Gruneau, P. *The effect of sample movement in fault detection using eddy currents* 385, 487
- Grimsdale, R. L., and Sinclare, P. H. *Design of housing-estate distribution systems using a digital computer* 727
- Grimsdale, R. L., Sumner, F. H., Tunis, C. J., and Kilburn, T. *A system for the automatic recognition of patterns* 160, 192
- Häggblom, H. *The spectral density of the a.m. noise in reflex klystrons* 656, 667
- Haine, M. E., and Vine, J. *An electron-trajectory tracer for use with the resistance network analogue* 376, 404, 667
- Hammond, P. *Calculation of the magnetic field of rotating machines—Part 1* 387, 557
- Hammond, P. *Electromagnetic energy transfer* 319, 387
- Harper, G. B. *Selection of insulation levels and tests for high-voltage transformers* 44, 380. 401, 738
- Harvey, A. F. *Microwave tubes—an introductory review with bibliography* 534
- Harvey, A. F. *Optical techniques at microwave frequencies* 167, 192
- Harvey, A. F. *Parallel-plate transmission systems for microwave frequencies* 167, 192
- Harvey, A. F. *Radio-frequency aspects of electronuclear accelerators* 42, 45
- Harwood, A. E., Scott, P., and Stonehouse, B. H. *The design of electro-mechanical auxiliaries directly associated with power-producing reactors* 153, 196, 397
- Hawkes, H. W. *A new method of generating a rotating radiation polar diagram* 167, 192
- Hibberd, R. G. *Transistors and associated semiconductor devices* 313, 333
- Hill, J. R., Hunt, A., Joyce, W. J., and Tompsett, D. H. *Field suppression of turbo-alternators* 660
- Howson, D. P., and Tucker, D. G. *Rectifier modulators with frequency-selective terminations* 727
- Hyde, F. J. *High-frequency power gain of the drift transistor* 314, 487
- Hyde, F. J. *An investigation of the current gain of a drift transistor at frequencies up to 105 Mc/s* 314, 487
- Hyde, F. J. *An investigation of the dependence of the current gain of a plane-alloy-junction transistor on emitter current and frequency* 314, 487
- Ismail, M. K. E., and Adkins, B. *Performance calculations of the capacitor motor using the transformer analogue analyser* 244, 248
- Jacks, E. *Discrimination between h.r.c. fuses* 44, 304, 334, 487
- Jacobsen, B. B. *Frequency patterns for multiple-radio-channel routes* 660
- James, F. H. *Method for the measurement of very high Q-factors of electromagnetic resonators* 110, 238, 263, 613
- Jha, C. S., and Daniels, A. R. *The starting of single-phase induction motors having asymmetrical stator windings in quadrature* 469, 487
- Jones, C. V. *Method of series summation and its application to the electric force in sphere-gaps* 174, 537

***Proceedings* papers and monographs** (contd.)

- Josephs, H. J. *Heaviside papers found at Paignton in 1957* 26, 45, 192
- Jurkus, A., and Robson, P. N. *Saturation effects in a travelling-wave parametric amplifier* 599, 713
- Karbowiak, A. E. *Some comments on the classification of waveguide modes* 599, 715
- Kayser, H.-G., Luerenbaum, K., Müller, Cl., Sauer, R., Stefaniak, H., and Wille, R. *Problems of engineering education* 319, 719
- Kesavamurthy, N., and Rajagopalan, P. K. *Eddy currents in solid iron due to alternating magnetic flux* 387, 557
- Kesavamurthy, N., and Rajagopalan, P. K. *Rise of flux in solid iron core due to impact excitation* 386, 557
- King, S.-Y. *Electric field near bundle conductors* 386, 557
- Knight, U. G. W. *Logical design of electrical networks using linear-programming methods* 728
- Kuffel, E. *Effect of irradiation on breakdown voltage of sphere-gaps in air under direct and alternating voltages* 110, 557
- Levy, R. *Guide to the practical application of Chebyshev functions to the design of microwave components* 386, 557
- Lewin, L. *Efficiency of a ferrite as a microwave mixer* 245, 557
- Lewin, L. *Ferrite boundary-value problem in a rectangular waveguide* 531, 667
- Lewin, L. *Phase measurements through tapered junctions* 314, 613
- Lindsey, C. H. *Square-loop ferrite core as a circuit-element* 110, 557
- Lubbock, J. K. *Optimization of a class of non-linear filters* 660
- McDonnell, D., and Perkins, W. R. *Interpolation and prediction of signals plus noise for infinite and finite smoothing times* 192
- Mackay, N. J., and Hardwick, E. *Electrical installations at Calder Hall* 228, 260, 397
- McKenzie, D. B. *Electrical material and components for aircraft power equipment operating at high temperatures* 487, 527
- McLeish, C. W., and Roger, R. S. *An investigation of high-frequency direction-finding errors caused by nearby vertical reradiators* 42, 45
- Manley, T. R., Rothwell, K., and Gray, W. *Application of low-pressure resins to some high-voltage switchgear designs* 660
- Mason, T. H., Aylett, P. D., and Birch, F. H. *Turbogenerator performance under exceptional operating conditions* 44, 239, 262, 264, 613
- Mayne, D. Q. *Transient response of band-pass filters to modulated signals* 174, 557
- Metson, G. H. *Conductivity of oxide cathodes—6* 192
- Metson, G. H., and Macartney, E. *Conductivity of oxide cathodes. 7—Solid semiconduction* 600
- Midgley, D. *Sliding-rotor induction motor* 593, 613
- Millard, G. H. *Measurement of non-linearity in cracked-carbon resistors* 45
- Missen, J. I. *Method for testing and establishing the rating of semiconductor rectifiers under dynamic conditions* 192
- Monteath, G. D., and Knight, P. *The performance of a balanced aerial when connected directly to a coaxial cable* 656, 738
- Moran, F. *Power-system automatic frequency control techniques* 102, 123, 248
- Morris, D. W., and Mitchell, G. *A multiple-direction universally-steerable aerial system for h.f. operation* 593, 667
- Palmer, L. S. *Examples of geoelectric surveys* 300, 338, 397
- Pannell, J. W. *Alternator with field-form envelope control* 656, 738
- Pick, T. S., and Readman, A. *Recognition of moving vehicles by electronic means* 95, 127, 192

Proceedings papers and monographs (contd.)
· Pitts, J. P. *Reliability and life of impregnated-paper capacitors* 110, 378, 405, 613
· Prescott, J. C., and El-Kharashi, A. K. *A method of measuring self-inductances applicable to large electrical machines* 243, 248
· Pressey, B. G., Ashwell, G. E., and Roberts, R. *Further studies of the deviation of low- and medium-frequency ground waves at a coast-line* 652, 667
· Prior, H. T., Chapman, D. J. R., and Whitehead, A. A. M. *The application of transistors to line communication equipment* 150, 194, 333
· Rayner, G. H. *Calibration of inductors at power and audio frequencies* 192
· Rhodes, J. *A method of locating dry joints in telecommunication cables* 531, 613
· Richards, D. L., and Swaffield, J. *Assessment of speech-communication links* 34, 52, 192
· Roberts, J. *Analogue treatment of eddy-current problems involving 2-dimensional fields* 413, 476
· Robson, T. S., and Jaskolski, T. M. J. *High-power television transmitters for bands IV and V* 650, 667
· Rogers, E. C., and Skipper, D. J. *Gaseous-discharge phenomena in h.v. d.c. cable dielectrics* 727
· Ryle, P. J. *Transmission and distribution at 66 kV and over* 242
· Salvage B. F., and Gibbons, J. A. M. *Impulse strength of impregnated-paper dielectrics used in h.v. cables* 728
· Saxton, J. A., and Harden, B. N. *The performance of directive aerials in complex u.h.f. fields* 313, 333
· Scholefield, H. H., Green, H. H. H., and Gossett, R. E. *Manufacture of waveguide parts by investment casting from frozen-mercury patterns* 469, 487
· Secker, P. E., and Guile, A. E. *Arc movement in a transverse magnetic field at atmospheric pressure* 469, 487
· Seeley, J. S. *The quarter-wave matching of dispersive materials* 38, 53, 192
· Seeley, J. S., and Brown, J. *The use of dispersive artificial dielectrics in a beam-scanning prism* 38, 53, 192
· Sharma, K. P. *The estimation of the reactance of a loss-free surface supporting surface waves* 469, 497
· Sharma, K. P. *An investigation of the excitation of radiation by surface waves* 166, 192
· Sketch, H. J. H., Shaw, P. A., and Splatt, R. J. K. *New method for observing the phenomena of commutation* 386
· Smolinski, A. K., and Zbikowski, M. *Time decrease of permeability in transformer steel* 192
· Solymar, L. *Note on the optimum design of non-uniform transmission lines* 661
· Sreenivasan, T. V. *Dynamic braking of 3-phase motors by capacitors* 385, 397
· Stephenson, L. M., and Barlow, H. E. M. *Power measurement at 4 Gc/s by the application of the Hall effect in a semiconductor* 42, 45
· Swaffield, J., and Richards, D. L. *Rating of speech links and performance of telephone networks* 34, 52, 192
· Swann, G. F. *Field strengths required for the reception of television in bands I, III, IV and V* 44, 379, 401, 667
· Taylor, W. K. *Pattern recognition by means of automatic analogue apparatus* 157, 192
· Thompson, A. M. *The cylindrical cross-capacitor as a calculable standard* 244, 333
· Thompson, A. M., and Archer, R. W. *A very precise short-period comparator for 100 kc/s frequency standards* 42, 45
· Thornton, E. P. G., and Booth, D. H. *Design and performance of the gas-filled cable system* 98, 125, 397

Proceedings papers and monographs (contd.)
· Tucker, D. G. *Input impedance of rectifier modulators* 727
· Twisleton, J. R. G. *Some properties of travelling-wave resonance* 599, 712
· Twisleton, J. R. G. *The transformation of admittance through a matching section and lossless waveguide junction* 167, 192
· Vigoureux, P. *Development of the formulae of electromagnetism in the M.K.S. system* 413, 476
· Walker, J. H. *Generator/motor problems in pumped-storage installations* 599
· Wardrop, K. W. *An analogue computer to evaluate the cost of changes in power on a power system* 469, 487
· Watt, D. A. *The design of electromagnetic pumps for liquid metals* 231, 248
· Welbourn, D. B., Spalding, D. B., and Ashdown, G. L. *Engineering education at the technical universities in Western Germany* 319, 718, 738
· White, E. L. C. *A frequency modulator for broadcasting transmitters utilizing over-all negative feedback* 385, 487
· Williams, A. D., and Gore, D. C. *Design and performance of a new low-noise triode for use up to 1000 Mc/s* 42, 45
· Williams, F. C., Laithwaite, E. R., and Eastham, J. F. *Development and design of spherical induction motors* 656, 738
· Williams, F. C., Laithwaite E. R., Eastham, J. F., and Piggott, L. S. *The Logmotor—a cylindrical brushless variable-speed induction motor* 655
· Williams, F. E., and Wilson, F. A. *Design of automatic sensitivity control for a new subscriber's telephone set—British Post Office 700-type telephone* 174, 381, 400, 487
Process industries, the problem of maintenance of electronic equipment in: Report of discussion on 488
Professional Engineers Appointments Board 506
Professional engineers, booklet entitled: Publication of 517
Programme machines on the Tube by R. Dell 88
Progress in plastics 345
Progress reviews 242, 313
Proud of our part by S. E. Goodall 1
Public mobile radio service 285, 705
Public mobile radiotelephone service by W. J. Bray 705
Puckle, O. S. *Numerical control of machine tools* 512
Pumped storage at Loch Awe 204

Q

Quebec, Oversea Representative for: Appointment of 331
Queensland Oversea Committee: Reports of 132, 344, 676, 744

R

Radiation from sun flares 357
Radiation hazards, training in 358
Radio and Telecommunication Section (*see also* Electronics and Communications Section)
· Address by Chairman, 1958–59: Summary of 23
· Chairman's remarks 124
· Meetings: Report of 52
· Soirée: Report of 54
· Sub-Committees: Constitution and work of 124
Radio Interference Committee: Appointment on 484
Radio Interference, International Special Committee on (*see* C.I.S.P.R.)
Radio service, public mobile 285 (*see also* 705)
Radiogramophone design 567
Radioisotope test for insulated wire 671
Radley, Sir Gordon. Proposal of vote of thanks to retiring President, T. E. Goldup 8
Railway electrification 623
Railways, modern control techniques on the: Report of discussion on 123
Rapid transit, book on 730
Rayner, G. H. Award of Mather Premium 485
Reactive power, sign of 534
Reading District Meetings: Reports of 56, 126, 406, 741
Reading of technologists, the 687
Reciprocal arrangements with engineering institutions oversea 259, 614
Reconstruction of the Institution building 134, 438, 711
Recruitment of professional electrical engineers by G. S. C. Lucas 135
Reece, M. P. *The vacuum switch and its application to 'power' switching* 275
Reflectometers 631
Register of members: Notification of changes of address 331, 670
Regulations for the Electrical Equipment of Aircraft (*see* Aircraft)
Regulations for the Electrical Equipment of Buildings (*see* Wiring Regulations)
Regulations for the Electrical Equipment of Ships (*see* Ships)
Remotely controlled television camera 573
Report, Annual, 1958–59 431
Reports, E.R.A. 175, 318, 390, 477, 600, 729
Representatives of The Institution on other bodies 64 (*see also* Appointments and nominations)
Research scholarships: Awards of 614
Responsibility, a 274
Retired members and those of long standing: waiving of subscriptions of 398
Retired members, subscriptions of: Revision of Council's rule 668
Review of the *Proceedings*, Parts A and B 32, 95, 149, 228, 300, 376, 464, 527, 589, 650, 712 (*see also Proceedings* papers and monographs)
· *Accurate measurement of g_m* by M. R. Child and D. J. Sargent 313
· *Acoustic design of small studios* by C. L. S. Gilford 149
· *Alternator with field-form envelope control* by J. W. Pannell 656
· *A.M. noise spectrum in reflex klystrons* by H. Häggblom 656
· *Analogue computer for costing power changes* by K. W. Wardrop 469
· *Applications of artificial dielectrics* by J. S. Seeley, J. Brown and A. Carne 38
· *Arc initiation and power-follow current* by L. L. Alston and F. M. Bruce 100
· *Arc movement in transverse magnetic field at atmospheric pressure* by P. E. Secker and A. E. Guile 469
· *Automatic graph plotter* by M. P. Atkinson, W. T. Bane and D. L. A. Barber 306
· *Auxiliaries for nuclear power stations* by A. E. Harwood, P. Scott and B. H. Stonehouse 153
· *Balanced aerial connected directly to coaxial cable* by G. D. Monteath and P. Knight 656
· *British and German engineering degrees* by D. B. Welbourn D. B. Spalding and G. L. Ashdown 718
· *Bus electronic scanning indicator* by T. S. Pick and A. Readman 95
· *Classification of waveguide modes* by A. E. Karbowiak 715
· *Coal-mining and electricity* by A. P. Foster 653
· *Coastal deviation of radio waves* by B. G. Pressey, G. E. Ashwell and R. Roberts 652
· *Comparator for 100 kc/s frequency standards* by A. M. Thompson and R. W. Archer 42
· *Cross-field generator for closed-loop systems* by A. R. Daniels 530
· *Cross-modulation distortion due to pulling effect in f.m. klystron* by D. T. Gjessing 234

Review of the *Proceedings*, Parts A and B (contd.)
· *Current gain of drift transistors* by F. J. Hyde 314
· *Current gain of plane-alloy-junction transistors* by F. J. Hyde 314
· *Cylindrical cross-capacitor for standard* by A. M. Thompson 244
· *Deltic locomotive, the* by C. M. Cock 155
· *Design of the gas-filled cable system* by E. P. G. Thornton and D. H. Booth 98
· *Diagram calculator for phase-sequence components* by F. de la Court Chard 244
· *Directive aerials in complex u.h.f. fields* by J. A. Saxton and B. N. Harden 313
· *Discrimination between h.r.c. fuses* by E. Jacks 304
· *Dynamic braking of 3-phase motors by capacitors* by T. V. Sreenivasan 385
· *Electric drives in the paper industry* by P. D. House 165
· *Electrical installations at Calder Hall* by N. J. Mackay and E. Hardwick 228
· *Electrical materials for aircraft power equipment* by D. B. McKenzie 527
· *Electrical supplies to power-station auxiliaries* by D. A. Dewison 464
· *Electrification of U.K.A.E.A. factories* by J. W. Binns and W. J. Outram 40
· *Electromagnetic pumps for liquid metals* by D. A. Watt 231
· *Electromagnetic variable-ratio torque convertor* by D. O. Bishop and G. S. Brosan 377
· *Electron-trajectory tracer* by M. E. Haine and J. Vine 376
· *Electronic servo simulator* by A. J. S. Davidson 242
· *Electronics in jet-engine control* by H. E. Coles 720
· *Electro-nuclear accelerators* by A. F. Harvey 42
· *Ferrite boundary-value problem in a rectangular waveguide* by L. Lewin 531
· *Ferromagnetic travelling-wave amplifiers* by P. J. B. Clarricoats 714
· *Field strengths for television reception* by G. F. Swann 379
· *Flanges on waveguide* by P. C. Butson and G. T. Thompson 244
· *Frequency modulator with over-all negative feedback* by E. L. C. White 385
· *Frozen-mercury technique for casting waveguide parts* by H. H. Scholefield, H. H. H. Green and R. E. Gossett 469
· *Generating a rotating radiation polar diagram* by H. W. Hawkes 167
· *Geoelectric surveys* by L. S. Palmer 300
· *Helix structures for pulsed travelling-wave tube* by G. W. Buckley and J. Gunson 233
· *Hemi-isotropic radiators for the S- or X-band* by E. G. A. Goodall 314
· *H.F. direction-finding errors* by C. W. McLeish and R. S. Roger 42
· *H.F. multidirectional aerial* by D. W. Morris and G. Mitchell 593
· *H.F. power gain of drift transistors* by F. J. Hyde 314
· *High-current-density thermionic emitters* by A. H. W. Beck 307
· *High-power u.h.f. television transmitters* by T. S. Robson and T. M. J. Jaskolski 650
· *High-quality microphones* by M. L. Gayford 589
· *H.V. circuit-breakers with insulated-steel-plate arc chutes* by F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton 311
· *Induction-motor development* by H. Myers 528
· *Influence of consumers' load/consumption characteristics on meteri ig practice* by L. B. S. Golds 302
· *Insulation failure* by J. A. Denham 723
· *Insulation levels and tests for h.v. transformers* by G. B. Harper 380
· *Integrally constructed waveguide assemblies* by G. Craven and V. H. Knight 314
· *Location of dry joints in telecommunication cables* by J. Rhodes 531

Review of the *Proceedings*, Parts A and B (contd.)
· *Logarithmic motor* by F. C. Williams, E. R. Laithwaite, J. F. Eastham and L. S. Piggott 655
· *Logical design in electronic circuits* by J. Houldsworth 383
· *Measurement of inductances of electrical machines* by J. C. Prescott and A. K. El-Kharashi 243
· *Measurements from U.S.S.R. earth satellites* by W. C. Bain and E. D. R. Shearman 313
· *Multi-cavity klystron with improved bandwidth* by H. J. Curnow and L. E. S. Mathias 229
· *New high-speed digital technique* by D. Eldridge 32
· *New low-noise triode for up to 1000 Mc/s* by A. D. Williams and D. C. Gore 42
· *N.P.L. caesium standard* by L. Essen, E. G. Hope and J. V. L. Parry 164
· *Nuclear energy from controlled thermonuclear reaction* by D. W. Fry (*see also* p. 198) 468
· *Optical techniques at microwave frequencies* by A. F. Harvey 167
· *Overhead lines at 66 kV and above* by P. J. Ryle 242
· *Parallel-plate transmission systems* by A. F. Harvey 167
· *Pattern recognition by digital computer* by R. L. Grimsdale, F. H. Sumner, C. J. Tunis and T. Kilburn 160
· *Pattern-recognition system* by W. K. Taylor 157
· *Performance of capacitor motor predicted by analyser* by M. K. E. Ismail and B. Adkins 244
· *Performance of speech links and telephone networks* by D. L. Richards and J. Swaffield 34
· *Permanent-magnet materials* by J. E. Gould 716
· *Perturbation method for circular waveguides containing ferrites* by P. J. B. Clarricoats 313
· *Phase measurements through tapered junctions* by L. Lewin 314
· *Power/frequency characteristics of the Grid and automatic frequency control* by M. Davies, F. Moran and J. I. Bird 102
· *Power measurement at 4 Gc/s using Hall effect* by L. M. Stephenson and H. E. M. Barlow 42
· *Problems of engineering education* by H.-G. Kayser, K. Luerenbaum, Cl. Müller, R. Sauer, H. Stefaniak and R. Wille 719
· *Q-factor measurements on electromagnetic resonators* by F. H. James 238
· *Radial cylindrical surface waves* by J. Brown and K. P. Sharma 166
· *Radiation by surface waves* by K. P. Sharma 166
· *Radiation from a cylindrical surface* by H. E. M. Barlow 167
· *Reactance of surface supporting surface waves* by K. P. Sharma 469
· *Reliability of impregnated-paper capacitors* by J. P. Pitts 378
· *Representation by electrolytic tank* by D. Chandra 466
· *Rotor leakage reactance and resistance of 3-phase induction motor* by M. V. Deshpande and T. R. Subrahmanyan 105
· *Sample movement in fault detection using eddy currents* by P. Graneau 385
· *Sensitivity control for new telephone set* by F. E. Williams and F. A. Wilson 381
· *Silicone electrical insulation* by J. H. Davis 152
· *Sliding-rotor induction motor* by D. Midgley 593
· *Speed control of squirrel-cage induction motor* by G. K. Creighton and W. M. Somerville 721
· *Spherical induction motors* by F. C. Williams, E. R. Laithwaite and J. F. Eastham 656
· *Standardization and simplification of switchgear* by M. J. L. Willison 309
· *Starting of single-phase induction motors* by C. S. Jha and A. R. Daniels 469
· *Starting of 3-phase induction motor on single-phase supply* by J. E. Brown and C. S. Jha 243
Subscriber trunk dialling by D. A. Barron 236
· *Transformation of admittance* by J. R. G. Twisleton 167

Review of the *Proceedings*, Parts A and B (contd.)
· *Transistor active filters using twin-T rejection networks* by A. E. Bachmann 167
· *Transistor digital computer* by R. C. M. Barnes and J. H. Stephen 33
· *Transistors and associated semiconductor devices* by R. G. Hibberd 313
· *Transistors in a.f. telephone line amplifiers* by H. G. Bassett, D. Thomson and P. E. Greenaway 230
· *Transistors in line communication* by H. T. Prior, D. J. R. Chapman and A. A. M. Whitehead 150
· *Transistors in phase-comparison carrier protection* by Colin Adamson and E. A. Talkhan 105
· *Travelling-wave parametric-amplifier theory* by A. L. Cullen 713
· *Travelling-wave parametric-amplifier theory* by A. Jurkus and P. N. Robson 713
· *Travelling-wave resonance* by J. R. G. Twisleton 712
· *Turbogenerator performance* by T. H. Mason, P. D. Aylett and F. H. Birch 239
Reviews, electrical engineering
· *Auxiliary equipment for fluorescent lighting* 212
· *Circuit trends in domestic sound and broadcast receivers* 567
· *Materials handling and automation* 689
· *Modern ferromagnetic materials* 417
Richards, D. L., and Swaffield, J. Award of an Electronics and Communications Section Premium 485
Robinson, B. C., and Winder, A. I. Award of a Utilization Section Premium 486
Rodwell, F. A. *Circuit trends in domestic sound and broadcast receivers* 567
Rogers, E. C. Award of a Measurement and Control Section Premium 485
Rowe, E. G. Report of lecture entitled *The application of statistical techniques to the electronic-valve industry* to Electronics and Communications Section 558
Royal Air Force: Appointment of representative on Electronics and Communications Section Committee 668
Royal Military College of Science, civilian studentships at: Conditions of award 121, 670
Royal Navy: Appointment of representative on Electronics and Communications Section Committee 668
Royal Society, Declaration on fair copying of scientific information 48
Royal Society Tercentenary: Celebration of 120
Rural communication systems by A. J. Barker 507
Rural electrification 565
Russia, patents delegation to 709
Rutherford College of Technology, Advisory Committee for Electrical Engineering: Nomination of representative on 413
Rylands, J. R. Nomination as an Ordinary Member of Council 258

S

Sagacious Mr. Cavendish, the by P. Hammond 582
Salomons Scholarship: Award to D. R. Fones 614
Sayers, D. P. Address as Chairman of Supply Section (1958–59) 22
Sayers, J. F., and Smyth, C. N. (*see* Smyth, C. N.)
Scholarships
· Awards of 614
· Council invite applications for 191
Schonland, B. F. J. Speaking at convention on thermonuclear processes 359
Science Museum Library, photoprint service 49
Science, postgraduate courses in (Liverpool University): Announcement of 122
Scientific information: Declaration on fair copying of 48
Scotland–Faeroes–Iceland cable 352
Scotland, first reactors for 362

Scottish Centre
· Annual General Meeting: Report of 493
· District Meetings: Report of 267
· Edinburgh Dinner: Report of 343
· Glasgow Dinner-Dance: Report of 58
· Jubilee Year. Arrangements for 675
· Meetings: Reports of 343, 409, 675
· Spring Meeting: Report of 493
Scottish Electrical Training Scheme: Report of 1959 conference of 636
Scottish Electronics and Measurements Group
· Formation of 743
· Meetings: Report of 743
Secker, P. E. Award of I.M.E.A. Scholarship 614
Section Committees (1959–60): Constitution of 412, 678
Self, S. A., Boot, H. A. H., and Foster, H. (*see* Boot, H. A. H.)
SEP, 40th anniversary of by R. Davis 524
Sheffield Graduate and Student Section: Report of week-end conference 342
Sheffield Sub-Centre
· Institution Summer Meeting 59, 284
· Meetings: Reports of 59, 202, 340, 342, 742
· N. Lincs. District Meeting: Report of 743
Shelley, I. J., and Wood, C. B. B. (*see* Wood, C. B. B.)
Ships, Committee on Regulations for the Electrical Equipment of: Appointments on 258, 413, 484
Shorter, D. E. L. Award of an Electronics and Communications Section Premium 485
Silicon-iron alloys 419
Silicones 697
Singapore/Malaya Joint Group: Report of activities 744
Single-shaft turbogenerators, largest (Drakelow power station) 709
Smart, D. W. *Bringing water and power to Kuwait* 574
Smoke detection 633
Smyth, C. N., and Sayers, J. F. Report of lecture entitled *Ultra-sound image camera* to Electronics and Communications Section 262
Snell (John) Premium: Award to E. P. G. Thornton and D. H. Booth 485
Some recent books 111, 176, 249, 320, 391, 478, 539, 602, 662, 730
· Ageron, P., Bonaldi, A., Gauzit, N., and Reis, T. (*Editors*) *Technologie des réacteurs nucléaires* 602
· Alt, F. L. *Electronic digital computers—their use in science and engineering* 176
· Amos, S. W. *Principles of transistor circuits* 539
· Amos, S. W., and Birkinshaw, D. C. *Television engineering—Vol. 4* 391
· Angelo, E. J., Jun. *Electronic circuits* 391
· Andé, F. *Die Schaltung der Leistungstransformatoren* 539
· Aseltine, J. A. *Transform method in linear system analysis* 249
· Ashby, Sir Eric. *Technology and the academics* 249
· Barnes, D. E., and Taylor, D. *Radiation hazards and protection* 176
· Beck, A. H. W. *Space-charge waves* 176
· Bendat, J. S. *Principles and applications of random noise theory* 249
· Benson, F. A., and Harrison, D. *Electric-circuit theory* 730
· Berkeley, E. C. *Symbolic logic and intelligent machines* 730
· Besserer, C. W. *Missile engineering handbook* 177
· Biondi, F. J. (*Editor*) *Transistor technology—Vol. 3* 176
· Birks, J. B., and Schulman, J. H. (Editors) *Progress in dielectrics—Vol. 1* 539
· Booth, A. D., Brandwood, L., and Cleave, J. P. *Mechanical resolution of linguistic problems* 540
· Bower, J. L., and Schultheiss, P. M. *Introduction to the design of servomechanisms* 177

Some recent books (contd.)
· Brooks, H. (*Editor*) *Advances in semiconductor science* 540
· Buckingham, H., and Price, E. M. *Electrotechnology for National Certificate courses—Vol. 3* 730
· Caldwell, S. H. *Switching circuits and logical design* 111
· Campbell, D. P. *Process dynamics* 320
· Carr, L. H. A., and Wood, J. C. *Patents for engineers* 540
· Carroll, J. M. *Modern transistor circuits* 602
· Cattermole, K. W. *Transistor circuits* 662
· Cauer, W. *Synthesis of linear communication networks—Vols. 1 and 2* 320
· Chappel, G. A. *Radio stations—installation, design and practice* 603
· Charpie, R. A., and Dunworth, J. V. (*Editors*) *Soviet reviews of nuclear science* 602
· Cheng, D. K. *Analysis of linear systems* 540
· Clarke, A. C. *Voice across the sea* 320
· Clason, W. E. (*Editor*) *Elsevier's dictionary of nuclear science and technology* 321
· Condoyannis, G. E. *Scientific Russian* 730
· Cotton, H., and Golding, E. W. *Foundations of electrical engineering—Vol. 2* 321
· Cotton, S. J. *Mathematics for telecommunications engineers* 602
· Culbertson, J. T. *Mathematics and logic for digital devices* 391
· Cunningham, W. J. *Introduction to non-linear analysis* 391
· Curtiss, L. F. *Introduction to neutron physics* 321
· Cusak, N. *The electrical and magnetic properties of solids* 541
· Davenport, W. B. and Root, W. L. *An introduction to the theory of random signals and noise* 249
· Donaldson, P. E. K. *Electronic apparatus for biological research* 321
· Dummer, G. W. A. *Modern electronic components* 322
· Dungey, J. W. *Cosmic electrodynamics* 322
· Eckman, D. P. *Automatic process control* 250
· Eichner, H., and Hein, H. *Reading German for scientists* 603
· Eisler, P. *Technology of printed circuits* 322
· Everitt, W. L. (*Editor*) *Fundamentals of radio and electronics* 322
· Fischer, H., and Mansur, L. C. (*Editors*) *Conference on extremely high temperatures* 392
· Frank, E. *Electrical measurement analysis* 541
· Fraser, W. *Telecommunications* 323
· Freebody, J. W. *Telegraphy* 323
· Freeman, J. J. *Principles of noise* 250
· Frisch, O. R. (*Consulting Editor*) *The nuclear handbook* 541
· Frost-Smith, E. H. *The theory and design of magnetic amplifiers* 323
· Gant, H. N. *Mobile radio telephones* 603
· Gavin, M. R., and Houldin, J. E. *Principles of electronics* 542
· Gibson, J. E., and Tuteur, F. B. *Control system components* 250
· Gillie, A. C. *Transistors* 662
· Glazier, E. V. D., and Lamont, H. R. L. *The Services textbook of radio. Vol. 5—Transmission and propagation* 542
· Godfrey, J. W., and Parr, G. *The technical writer* 392
· Grabbe, E. M., Ramo, S. and Wooldridge, D. E. (*Editors*) *Handbook of automation, computation and control—Vol. 1* 251
· Goodman, L. Landon *Automation today and tomorrow* 603
· Hamilton J. J. *Reflex klystrons* 478
· Hannay, N. B. (*Editor*) *Semiconductors* 542
· Harrington, R. F. *Introduction to electromagnetic engineering* 478
· Haus, H. A., and Adler, R. B. *Circuit theory of linear noisy networks* 731
· Hayt, W. H. *Engineering electromagnetics* 542

Some recent books (contd.)
· Hecht, A. *Elektrokeramik* 603
· Henney, K., and Walsh, C. (*Editors*) *Electronic components handbook—Vol. 2* 324
· Henriet, P. *Fonctionnement et protection des réseaux de transport d'électricité* 324
· Higonnet, R. A., and Grea, R. A. *Logical design of electrical circuits* 324
· Hollingdale, S. H. *High speed computing methods and applications* 478
· Hooper, J. E., and Scharff, M. *The cosmic radiation* 251
· Humphrey, W. S., Jun. *Switching circuits with computer applications* 251
· Hurley, R. B. *Junction transistor electronics* 324
· Ingham, H., and Harrington, L. Taylor *Interfirm comparison for management—Vol. 3* 111
· Jelley, J. V. *Cerenkov radiation and its applications* 478
· Jury, E. I. *Sampled-data control systems* 393
· Katz, H. W. (*Editor*) *Solid state magnetic and dielectric devices* 662
· Kirchmayer, L. K. *Economic operation of power systems* 603
· Kleen, W. J., and Pöschl, K. *Einführung in die Mikrowellenelectronik—Vol. 2* 481
· Knoll, Max *Materials and processes of electron devices* 662
· Koch, J. (*Editor*), Dawton, R. H. V. M., Smith, M. L., and Walcher, W. *Electromagnetic isotope separators and applications of electromagnetically enriched isotopes* 325
· Kovács, K. P., and Racz, I. *Transiente Vorgange in Wechselstrommaschinen—Vols. 1 and 2* 604
· Ku, Y. H. *Analysis and control of nonlinear systems* 111
· Ku, Y. H. *Electric energy conversion* 604
· Lawson, W. D., and Neilson, S. *Preparation of single crystals* 604
· Levell, D. A. *Pulse and time-based generators* 325
· Loeb, L. B. *Static electrification* 663
· McCrensky, E. *Scientific manpower in Europe* 605
· Martin, T. L. *Physical basis for electrical engineering* 479
· Márton, L. (*Editor*) *Advances in electronics and electron physics—Vol. 10* 543
· Mason, W. P. *Physical acoustics and the properties of solids* 252
· Massey, H. S. W., and Boyd, R. L. F. *The upper atmosphere* 252
· Massey, H. S. W., and Kestelman, H. *Ancillary mathematics* 325
· Maxwell, I. R., Mummery, P. W., and Sporn, P. (*Editors*) *The economics of nuclear power—Vol. 2* 663
· Millman, J. *Vacuum-tube and semiconductor electronics* 252
· Molloy, R. E. (*Editor*) *Medical electrical equipment* 253
· Moss, T. S. *Optical properties of semi-conductors* 543
· Murphy, G. J. *Control engineering* 664
· Murphy, J. S. *Basics of digital computers* 112
· Myers, W. R. *Theoretical electromagnetism* 605
· Newstead, G. *General circuit theory* 605
· Nixon, F. E. *Principles of automatic controls* 325
· Noltingk, B. E. *The human element in research management* 731
· Olson, H. F. *Dynamical analogies* 326
· Otto, C. A. (*Editor*) *Electric furnaces* 326
· Page, C. H. *The algebra of electronics* 605
· Pannett, W. E. *Radio engineering formulae and calculations* 544
· Partridge, G. R. *Principles of electronic instruments* 113
· Perrine, J. O. *Physics and mathematics in electrical communication* 112

Some recent books (contd.)
- **Pressman, A. I.** *Design of transistorized circuits for digital computers* 605
- **Pullen, K. A., Jun.** *Conductance design of active circuits* 479
- **Ragazzini, J. R., and Franklin, G. F.** *Sampled-data control systems* 326
- **Ratcliffe, J. A.** *The magneto-ionic theory and its applications to the ionosphere* 393
- **Renton, R. N.** *Telecommunications principles (in M.K.S. units)* 327
- **Richards, E. A.** *Metal rectifier engineering* 393
- **Roberts, A.** *Underground lighting in mines, shafts and tunnels* 113
- **Roller, D. H. D.** *The De magnete of William Gilbert* 606
- **Sandretto, P. C.** *Electronic navigation engineering* 479
- **Say, M. G.** *The performance and design of alternating current machines* 177
- **Seeley, S.** *Electron-tube circuits* 178
- **Seely, S.** *Introduction to electromagnetic fields* 253
- **Seshu, S., and Balabanian, N.** *Linear network analysis* 606
- **Shepherd, A. A.** *An introduction to the theory and practice of semiconductors* 113
- **Shepherd, J., Morton, A. H., and Spence, L. F.** *Higher electrical engineering* 479
- **Shive, J. N.** *The properties, physics and design of semiconductor devices* 665
- **Singer, C., Holmyard, E. J., Hall, A. R., and Williams, T. I. (*Editors*)** *A history of technology. Vol. 4—The industrial revolution* 480
- **Singer, T. E. R. (*Editor*)** *Information and communication practice in industry* 178
- **Sinnott, M. J.** *The solid state for engineers* 541
- **Smith, C. V. L.** *Electronic digital computers* 606
- **Smith, G. W., and Wood, R. C.** *Principles of analog computation* 664
- **Smith, L. G. (*Editor*)** *Recent advances in atmospheric electricity* 731
- **Smullin, L. D., and Haus, H. A. (Editors)** *Noise in electron devices* 606
- **Spreadbury, F. G.** *Electricity in aircraft* 178
- **Stanford, E. G., and Fearon, J. H. (Editors)** *Progress in non-destructive testing—Vol. 1* 480
- **Stewart, W. Earl** *Magnetic recording techniques* 607
- **Stigant, S. Austin** *The elements of determinants, matrices and tensors for engineers* 732
- **Swann, H. W.** *Electrical safety* 481
- **Taube M., and Wooster, H. (*Editors*)** *Information storage and retrieval* 732
- **Taylor, E. Openshaw** *Nuclear power plant* 544
- **Taylor, E. Openshaw (*Editor*)** *Nuclear reactors for power generation* 178
- **Thomson, J., and Callick, E. B.** *Electron physics and technology* 327
- **Truxal, J. G. (*Editor*)** *Control engineers' handbook* 327
- **Tuttle, D. F., Jun.** *Network synthesis—Vol. 1* 179
- **United States Department of the Army** *English–Russian and Russian–English electronics dictionary* 393
- **Venables, P. F. R.** *Sandwich courses* 607
- **Vilbig, F.** *Lehrbuch der hochfrequenztechnik—Vol. 2* 544
- **Voge, J.** *Les tubes aux hyperfréquences* 481
- **Wagner, T. C. G.** *Analytical transients* 664
- **Wait, J. R.** *Electromagnetic radiation from cylindrical structures* 607
- **Wakefield, G. G. (*Editor*)** *Aircraft electrical engineering* 607
- **Walton, G. N.** *Glove boxes and shielded cells* 179
- **Warfield, J. N.** *Introduction to electronic analog computers* 664
- **Watkins, D. A.** *Topics in electromagnetic theory* 544
- **Weil, B. H. (*Editor*)** *Technical editing* 179

Some recent books (contd.)
- **Welch, G. B.** *Wave propagation and antennas* 544
- **White, D. C., and Woodson, H. H.** *Electromechanical energy conversion* 481
- **Wolfendale, E. (*Editor*)** *The junction transistor and its applications* 254
- **Wood, W. S.** *Theory of electrical machines* 180
- **Yarwood, J.** *Atomic physics* 254
- **Zajic, Vladislav** *High-voltage circuit-breakers* 253
- **Ziel, A. van der** *Fluctuation phenomena in semiconductors* 543
- **Zworykin, V. K., Ramberg, E. G., and Flory, L. E.** *Television in science and industry* 180

Some recent developments in electrical insulation by J. Ashmore 695

Somerville, W. M., and Creighton, G. K. (*see* Creighton, G. K.)

Sound and broadcast receivers (domestic), circuit trends in by F. A. Rodwell 567

Sound, the dimensions of 710

South Australia Oversea Committee
- Appointment of Honorary Secretary 190
- Report of 132

South East London Technical College: Nomination of representative on Electrical Engineering Consultative Committee of 485

South-East Scotland Sub-Centre
- Annual General Meeting: Report of 410
- Meeting: Report of 743

South Midland Centre: Address by Chairman, 1958–59, article based on 695

South Midland Supply and Utilization Group: Report of meetings 560

South Shields Marine and Technical College: Nomination of representative on Governing Body 485

South-West Scotland Sub-Centre: Report of meeting 743

Southern Centre
- Annual Dinner and Dance: Report of 342
- Dinner-Dance (Brighton): Report of 409
- District Meeting: Report of 200
- Meetings: Report of 267

Soviet Union, automatic control in the by A. Tustin 521

Sowter, G. A. V. Nomination as an Ordinary Member of Council 258

Space research and earth satellites 499

Space Research, National Committee on: Nomination of representative on 331

Space-research vehicles, electronic instruments in by R. L. F. Boyd 457

Spanish National Committee of World Power Conference: Announcement of Sectional meeting in Madrid 556

Special Advisory Committee of the Council: Constitution and terms of reference 649

Special General Meetings (*see* Meetings)

Speirs C. W.
- Honorary Membership:
  Election to 190
  Presentation of Certificate to 353

Squire, P. J. Lecture entitled *The World Bank—what it is, what it does, and how it works* to Supply Section 261, 617

Stafford College of Technology: Nomination of representative on Governing Body 398

Standardization of the yard and the pound 74

Standards, British: Publication of 318, 390, 600, 729

Standards, National Bureau of: Publications of 319, 601

Starr, A. T. *Some case-histories of business computers in the U.S.A.* 347

Statistical techniques, the application of, to the electronic-valve industry: Lecture to Electronics and Communications Section by E. G. Rowe 558

Statistics and engineering by M. D. McCarthy 700

S.T.D., popularity of 472

Steel structures, proposed code of practice on prevention of corrosion of: Nomination of representative on exploratory committee on 485

Stereophonic sound recording, reproduction and broadcasting, convention on:
- Announcement of 49
- Programme of 173
- Publication of papers and discussions 670
- Report of 710

Stockport College for Further Education: Nomination of representative on Engineering Advisory Committee 331

Storage and manipulation of information in the brain by R. L. Beurle 75

Storey, E. E. Appointed Honorary Secretary of South Australia Oversea Committee 190

Stuart, P. R., Kalman, P. G., and Gabor, D. (*see* Gabor, D.)

Student Scholarships: Awards of 614

Students' Quarterly Journal
- Contents 259, 486, 670
- Subscriptions to 259

Students' subscriptions: Reduction during period of National Service 331, 670

Submarine telephone cables, more calls on 549

Subscriber trunk dialling 10, 472

Subscriptions (annual) and entrance fees 525

Subscriptions (Institution)
- Income-tax relief on 258, 399, 556
- New rates of 525
- Reduction to Graduate and Student members during period of National Service 331, 670
- Retired members: Revision of Council's rule 668
- Waiving of, for retired members, and those of long standing 398

Subscriptions, reduced, for technical periodicals of other engineering institutions 737

Summer Meeting (*see* Meetings)

Supply-industry university scholarships 517

Supply Section
- Address by Chairman, 1958–59: Summary of 22
- Annual Lecture entitled *The World Bank—what it is, what it does, and how it works* by P. J. Squire 261, 617
- Chairman's remarks 617
- Committee, 1959–60:
  Constitution of 412, 678
  New members of 560
- Dinner-Dance: Report of 335
- Joint Meeting with Measurement and Control Section: Report of 123
- Meetings: Reports of 125, 196, 335, 401, 490, 617
- Premiums: Awards of 485
- Programme of 56
- Provincial Groups: Meetings of 197, 559
- Summer visit to Dublin 262, 673
- Summer visit to Thames Valley 489

Swaffield, J., and Richards, D. L. (*see* Richards, D. L.)

Swan Premium: Award to C. M. Cock 485

Swansea Technical College, Advisory Committee for Engineering: Nomination of representatives on 47

Symposia
- Communications (national): Announcement of 332
- Electrical installations in buildings 55, 398, 560
- Mechanization of thought processes: Report of 31
- Reliability and quality control in electronics (6th national): Announcement of 557

T

Taverner, A. I. Letter of Commendation 486

Technical literature and technologists 687

Technical Press: Articles in 557

Technical publications 175, 318, 390, 477, 600, 729

Telecommunications, on the conceivable future of: Lecture, Announcement of 257

Telephones on trains 361

Television camera (remotely controlled) 573

Television film by transatlantic cable 463

Television stations in East Anglia 553

Terry, V. J., and Wright, E. P. G. Lecture on *Errors in data transmission* to Electronics and Communications, and Measurement and Control Sections 263
Thermonuclear processes, convention on
· Papers and contributions: List of 227
· Programme for 226
· Publication of papers and discussions 669
· Report of 359
Thermonuclear reaction (controlled), nuclear energy from: Lecture by D. W. Fry 198, 468
Thomas, H. A. Thirtieth Faraday Lecture, on *Automation* 147, 267, 268, 341, 342, 343, 407, 408
Thomas, L. A. Opening of Measurement and Control Section discussion on *Ferroelectrics* 51
Thompson, G. T., Angell, B. C., Foot, J. B. L., and Lucas, W. J. (*see* Angell, B. C.)
Thompson (Silvanus) Premium: Award to J. J. Hill 485
Thompson (Silvanus) Scholarship: Award to P. N. T. Wells 614
Thomson, Sir George. Speaking at convention on thermonuclear processes 361
Thorne, T. G., and Clegg, J. E. (*see* Clegg, J. E.)
Thornton, E. P. G., and Booth, D. H. Award of John Snell Premium 485
Thought processes, mechanization of: Report of symposium on 31
Three-year education programme 285
Tie for members: Prices of 191, 736
To be an engineer 517
To promote the advancement of electrical science by R. C. Winton 586
Traction 210
Traffic Engineering Study Group: Establishment of 556
Training in radiation hazards 358
Training Regulations: Publication of 709
Trains, electronic recorders for 671
Trains, telephones on 361
Transfer machines 691
Transistor characteristics and their measurement 295, 296, 299
Transistor convention 273
Transistor materials 294, 295
Transistor technology and design and manufacture 297, 298
Transistors 569
Transistors and associated semiconductor devices, international convention on
· Foreword on 273
· Opening address by the Rt. Hon. the Viscount Hailsham 190
· Papers and contributions: List of 294
· Reports of 491, 586
Transistors, applications of 296, 297, 298, 299
Transistors as circuit-elements 299
Transistors, basic theory of 295
Transmission (long-distance) by waveguide, convention on 24, 25, 195, 486
Transmission of news film over the transatlantic cable: Announcement of lecture by C. B. B. Wood and I. J. Shelley 463
Trends in Post Office telephone-exchange equipment by J. A. Lawrence 10
Trinidad and Tobago Joint Group: Reports from 268, 343, 494, 563, 676
Tube, programme machines on the by R. Dell 88
Turbidimeters 632
Turbinia Memorial: Appeal for subscriptions to 670
Turbogenerators, largest single-shaft (Drakelow power station) 709
Turner, G. P. Award of Duddell Scholarship 614
Tustin, A. *Automatic control in the Soviet Union* 521
Tustin, A., Allanson, J. T., Layton, J. M., and Jakeways, R. J. Award of a Measurement and Control Section Premium 485
200MW turbogenerators 640

U

Uganda: Blowing up the Nile source 564
U.K.A.E.A., fifth annual report 1958–59: Publication of 601, 729
Ultra-sound image camera: Lecture to Electronics and Communications Section by C. N. Smyth and J. F. Sayers 262
Ultraviolet radiation 357
United Nations: Publications of 390, 601, 729
United States Department of Commerce: Publications of 601
United States of America: Honorary Secretary's report 344
U.S.A., women graduates in the 581
U.S.S.R., automatic controls in the: Report on 556
U.S.S.R., British control experts visit to 373
Utilization Section
· Address by Chairman, 1958–59: Summary of 20
· Annual Dinner-Dance (1959): Report of 261
· Annual Dinner-Dance (1960): Announcement of 674
Article on 18
· Chairman's remarks 125, 616, 674
· Committee, 1959–60:
Constitution of 412, 679
Government Departments, representatives of 668
New members of 560
· Electrical installations in buildings, provision of adequate, symposium on: Reports of 55, 398, 560
· Groups: Chairman's note on 402
· Joint Meeting with London Graduate and Student Section 125, 334
· Joint Meeting with Measurement and Control Section: Report of 197
· Lecture entitled *Lighting and architecture* by J. Waldram: Report of 488
· Meetings: Reports of 54, 260, 334, 488, 739
· Premiums. Awards of 485
· Summer visit (1959) 125, 403
· *What's in a name?* 334

V

Vacuum Science and Technology, Joint British Committee for:
· Formation of 738
· Nomination of representatives on 554
Vacuum switch and its application to 'power' switching by M. P. Reece 275
Van Atta, Chester. Speaking at convention on thermonuclear processes 360
Veale Committee 358
V.H.F. sound coverage and B.B.C. television 416

W

Wairakei geothermal station 83
Waldram, J. M. Lecture entitled *Lighting and architecture* to Utilization Section 488
Wales (Rural), Council for the Preservation of: Nomination of representative on General Committee 398
Walker, J. H., and Kerruish, N. Award of a Supply Section Premium 485
Walsh, John W. T. *The Illuminating Engineering Society 1909–1959* 221
Walsh, P. *Electrical floor-warming* 637
War Office: Appointment of representative on Utilization Section Committee 668
Wardrop, F. R. Appointed Deputy Oversea Representative for Malaya and Singapore 413
Waveguide, convention on long-distance transmission by 24, 25, 195, 486
Webb, J. K. Address as Chairman of Measurement and Control Section (1958–59) 21
Webb, W. J., and Ginger, L. A. M. Opening of discussion on *Modern control techniques on the railways* before the Measurement and Control Section 123
Weftless glass tape 696
Wells, P. N. T. Award of Silvanus Thompson Scholarship 614
West African Joint Group: Report of activities 344
West Wales (Swansea) Sub-Centre
· Annual Dinner-Dance: Report of 268
· Meeting: Reports of 268, 409
· Summer visit: Report of 561
Western Australia Oversea Committee: Report of activities of 406
Western Centre
· Annual Dinner-Dance 200, 410
· District Meeting: Report of 268
· Summer Meeting 201, 410
Western Supply Group: Reports of meetings 200, 559, 675
Western Utilization Group: Report of meetings 59
Wheatcroft, E. L. E. *Electricity from geothermal steam* 83
Whitworth Foundation awards: Particulars of 399
Wilcox, T. W., Lyon, G., and Winfield, F. C. (*see* Winfield, F. C.)
Williams, F. E., and Carter, F. C. Lecture entitled *The new Post Office 700-type telephone* to Electronics and Communications Section 400
Williamson, D. T. N. Opening of Measurement and Control Section discussion on *Electronic control of machine tools* 50
Winder, A. I., and Robinson, B. C. (*see* Robinson, B. C.)
Winfield, F. C., Wilcox, T. W., and Lyon, G. Award of John Hopkinson Premium 485
Winfrith Heath, joint European undertaking at 146, 577
Winfrith, new atomic energy establishment at 511
Winton, R. C. *To promote the advancement of electrical science* 586
Wiring Regulations Committee: Appointments on 47, 190, 258, 331, 398, 484, 668
Wiring Regulations—recent interpretations 374
Women graduates in the U.S.A. 581
Women in engineering: Report of discussion on 578
Women's Engineering Society
· Nomination of representative on Council of 554
· Programme for 1959–60 session 671
Wood, C. B. B., and Shelley, I. J. Announcement of lecture entitled *Transmission of news film over the transatlantic cable* 463
Work of C.C.I.R. in Los Angeles 523
Works, Ministry of: Appointment of representative on Utilization Section Committee 668
World Bank—what it is, what it does and how it works: Annual Lecture to Supply Section by P. J. Squire 261, 617
World Power Conference
· Argentina: Readmission of 556
· Madrid, Sectional meeting in: Announcement of 556
· Melbourne, 6th plenary conference in: Theme of 556
· New members: Election of 556
· Rome, International Executive Council meeting in: Report of 556
Wright, E. P. G., and Terry, V. J. (*see* Terry, V. J.)

Y

Yard and pound, standardization of 74
Yorkshire Council for Further Education
· Coal Mining Advisory Committee: Nomination of representative on 485
· Electrical Engineering Committee: Nomination of representative on 413

Z

Zenith reactor 511, 577

'Progress!' said the oldest rabbit. 'Pah! When I was a young bunny they only 'ad single Salt Glazed Pipes down 'ere. Now they got 'em in blooming great bundles and you 'ave to climb up and down blinking ladders to get across the road. Where's it going to end, eh?'

'Where indeed?' said Baron Rabbit. 'Those over there are in bundles of nine, and, by the way, they are conduits, not pipes. They make them like that to save time and labour in the laying. And the fact that you can get Salt Glazed Conduits in multiples is only one of their advantages. They're glassy smooth inside to prevent abrasion of the cable, they're impermeable, resistant to soil acids, durable —'

'Ho yes? That's all very int'resting', said the oldest rabbit. 'Now give us a shove up this perishing ladder, will yer?'

Salt Glazed Clay Conduits – for cables, for ever

NATIONAL SALT GLAZED PIPE MANUFACTURERS' ASSOCIATION

Solid economic arguments for a new approach to insulated cables

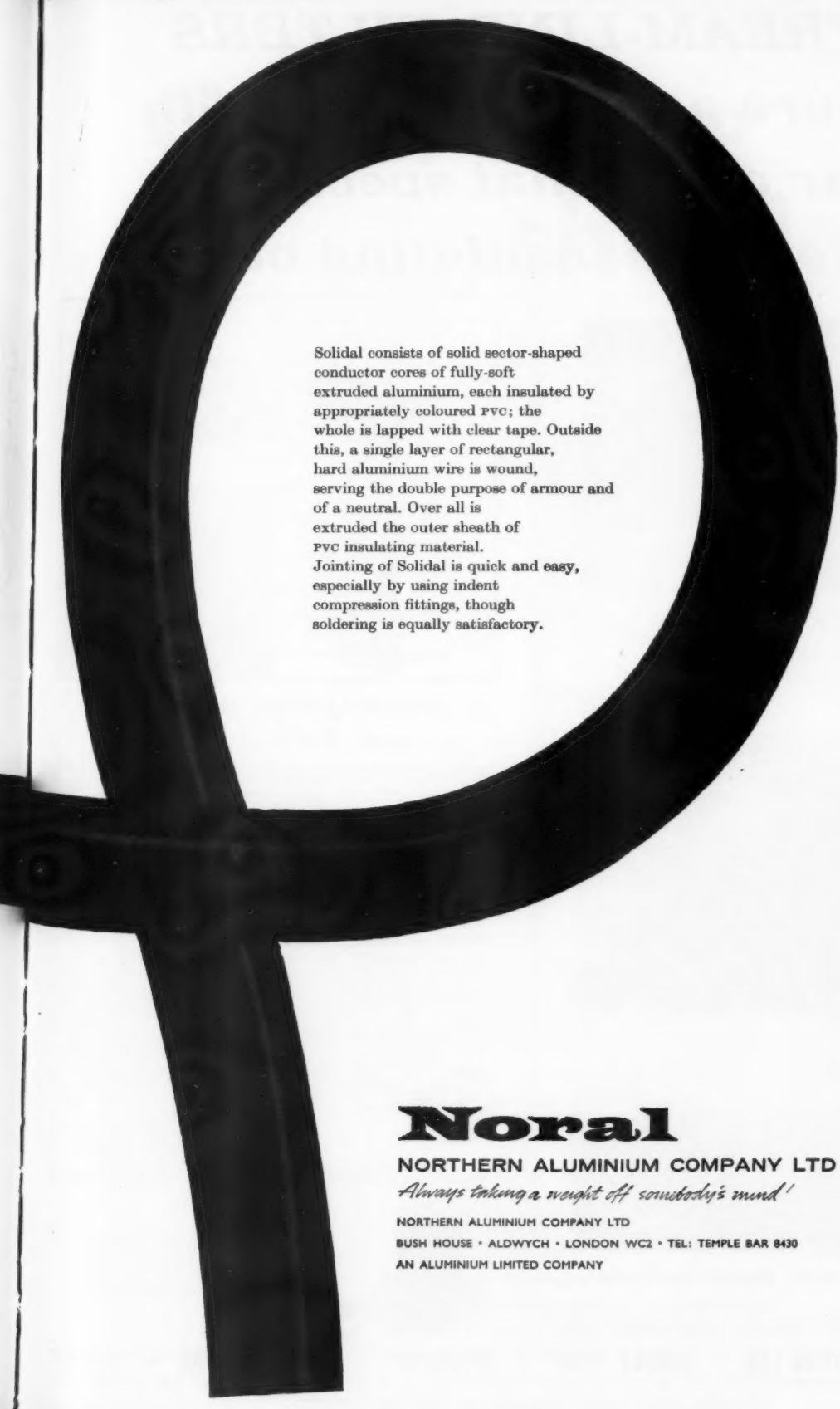
This is a new design of electric cable – in aluminium, which is not only a good conductor but a cheap one. By using solid instead of stranded conductors, and plastic insulation, this new Solidal cable achieves notable compactness and simplicity of jointing, and is economically most attractive. It is also very light and the solid conductors are no bar to easy manipulation.

The design and development of Solidal are an example of the forward thinking and research resources of the companies in the Aluminium Limited Group. We do not ourselves make or market Solidal, but will gladly send you further information, including the names of suppliers.

If you have a specific problem, in any field, that aluminium might solve, why not get in touch with Noral?

SOLIDAL

- Economical
- Readily manipulated
- Easily jointed



Solidal consists of solid sector-shaped conductor cores of fully-soft extruded aluminium, each insulated by appropriately coloured PVC; the whole is lapped with clear tape. Outside this, a single layer of rectangular, hard aluminium wire is wound, serving the double purpose of armour and of a neutral. Over all is extruded the outer sheath of PVC insulating material. Jointing of Solidal is quick and easy, especially by using indent compression fittings, though soldering is equally satisfactory.

Noral

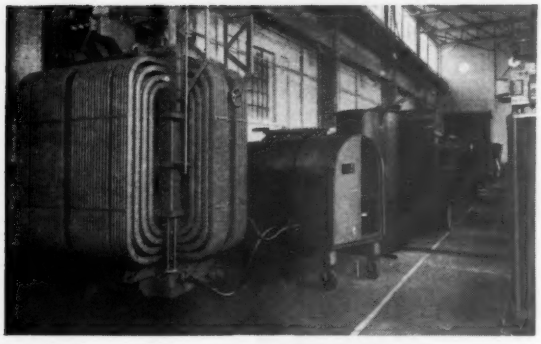
NORTHERN ALUMINIUM COMPANY LTD

Always taking a weight off somebody's mind!

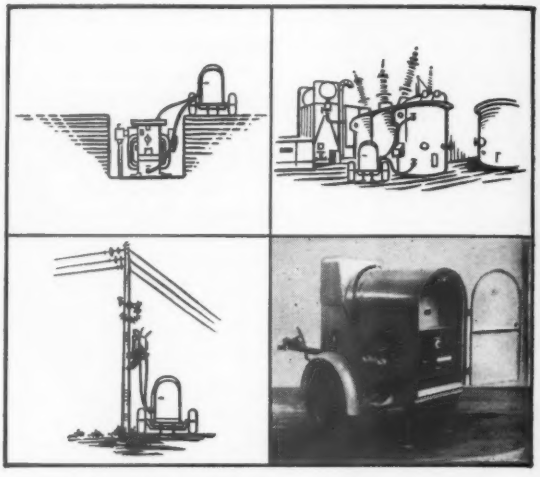
NORTHERN ALUMINIUM COMPANY LTD
BUSH HOUSE • ALDWYCH • LONDON WC2 • TEL: TEMPLE BAR 8430
AN ALUMINIUM LIMITED COMPANY

TBW/T35

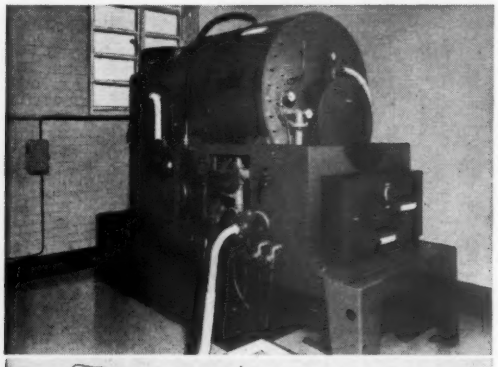
STREAM-LINE FILTERS
ensure a dielectric strength far above that specified for new insulating oil

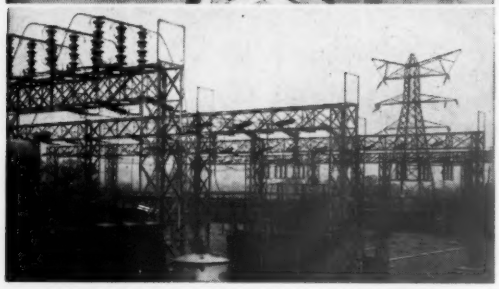


At transformer manufacturers' works



At sites above, below and at ground level



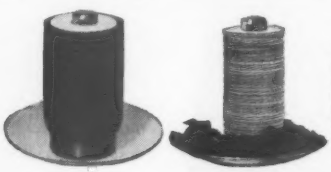


At electrical installations

The Stream-Line filter, embodying filtering elements, heating chamber and vacuum receiver, is the most perfect practical method of removing all traces of solid matter, water vapour and gases from insulating oil. The filter elements are built up of special paper discs under maintained end-compression so that even the finest impurities are held back at the paper edges.

The well-known "CN" (Medium Vacuum) types for servicing insulating oil in transformers and switchgear employ a vacuum of 28″/29″ Hg. The "CN-HV" (High Vacuum) range for servicing equipment in the manufacturers' works operates at pressures in the order of 0.1 mm. Hg.

Many applications of interest to all electrical plant manufacturers and supply undertakings are fully described with relevant technical data in a 16-page booklet available on request. Please write for Catalogue W.1031.



Solid impurities in the oil are deposited in their entirety at the paper edges. Cleaning is effected simply by a reverse flow of compressed air.

STREAM-LINE FILTERS LTD • HENLEY PARK • NORMANDY • NR. GUILDFORD • SURREY

Telephones: Normandy 3311-3

Telegrams: Edgefilt, Guildford.

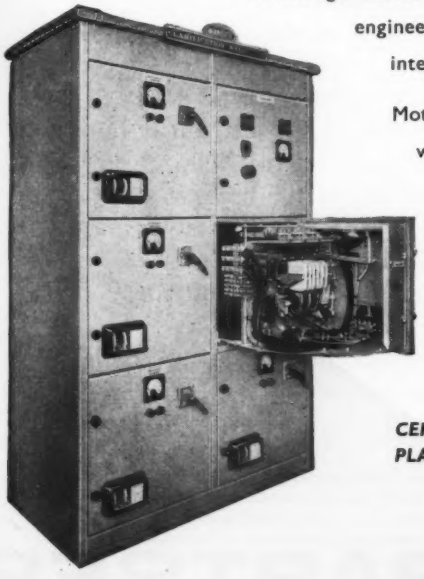
A member of the VOKES Group with world-wide representation

SF.100

Controlling the flow

Production must flow in a steady stream . . . from material and component stock, through machinery or processing, to the finished stage.

The conveyors that speed this stream, the machines it feeds, the processing plant through which it passes . . . these, and the many main or ancillary equipments that serve the flow, are being conceived by today's engineers as studies in grouped or integrated control.



Motor control centres by Brookhirst Igranic, who give consultant service on control problems, are integrally reliable, easy to install and maintain, with easily interchangeable units, and easily modified or extended.

CENTRALISED, STANDARDISED PLANT & PROCESS CONTROL
with Brookhirst Igranic motor control centres

BSI

Metal Industries Group

BROOKHIRST IGRANIC LIMITED

Sales Headquarters: **BEDFORD WORKS • BEDFORD** • *Works at:* **BEDFORD & CHESTER**

Area Offices: Birmingham Bristol Cardiff East Anglia Glasgow Leeds London Manchester Mid-Southern Newcastle Nottingham Sheffield

Makers of Britain's biggest range of electrical control equipment

BL26

Blaise Pascal (1623-1662)
Inventor of the first calculating machine

Pioneers...

The calculating machine was invented in 1641 by Blaise Pascal, an 18-year-old Frenchman, who used a series of geared wheels each having ten teeth numbered 0 to 9. Pascal's machine was large and unwieldy and was capable only of addition. It was not until 1874 that Willgodt Th. Odhner, a Swede, developed the first compact calculator for addition, subtraction, multiplication and division and thus inspired the tremendous advances which have since been made in the field of 'mechanical thought.'

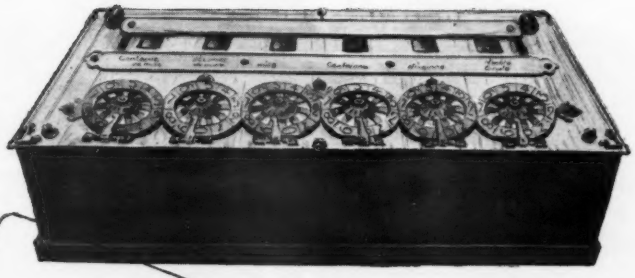
Like Pascal's calculator, the first contactors were cumbersome devices of limited scope; the trend in design has therefore been towards smaller, more efficient units having a wider application. This trend reached its peak in 1952 when the Crabtree Company introduced the first British 'block type' contactor of compact rectangular shape. It was designed for single or multiple assembly on a standard backplate to give an almost unlimited variety of control arrangements — a technique which is now being widely followed throughout the world.

The development of the 'block type' contactor exemplifies the Crabtree tradition of leadership in design, an influence which is being increasingly appreciated in the field of electrical control equipment.

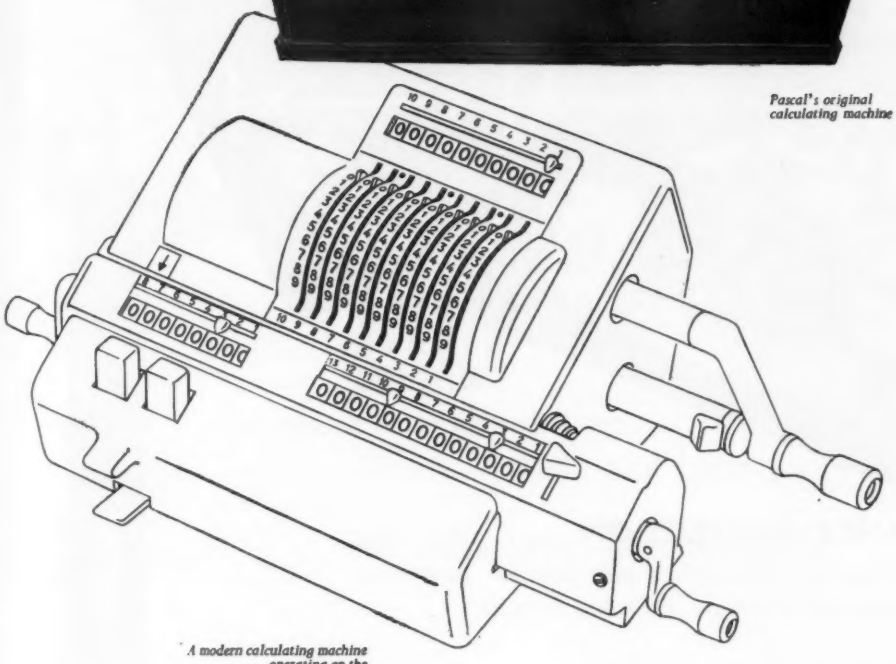
CRABTREE

J. A. CRABTREE & CO. LTD., LINCOLN WORKS, WALSALL

Manufacturers of Electrical



Pascal's original calculating machine



A modern calculating machine operating on the "pin-wheel" system

Control Gear

Air-break contactor starters for motors up to 70 h.p. Oil-break contactor starters for motors up to 15 h.p. Hand-operated starters for small motors. Remote push-button stations for general purpose, weatherproof and flameproof applications. Limit switches. Pilot light and indicator units. On-load isolating switches.

Circuit Breakers

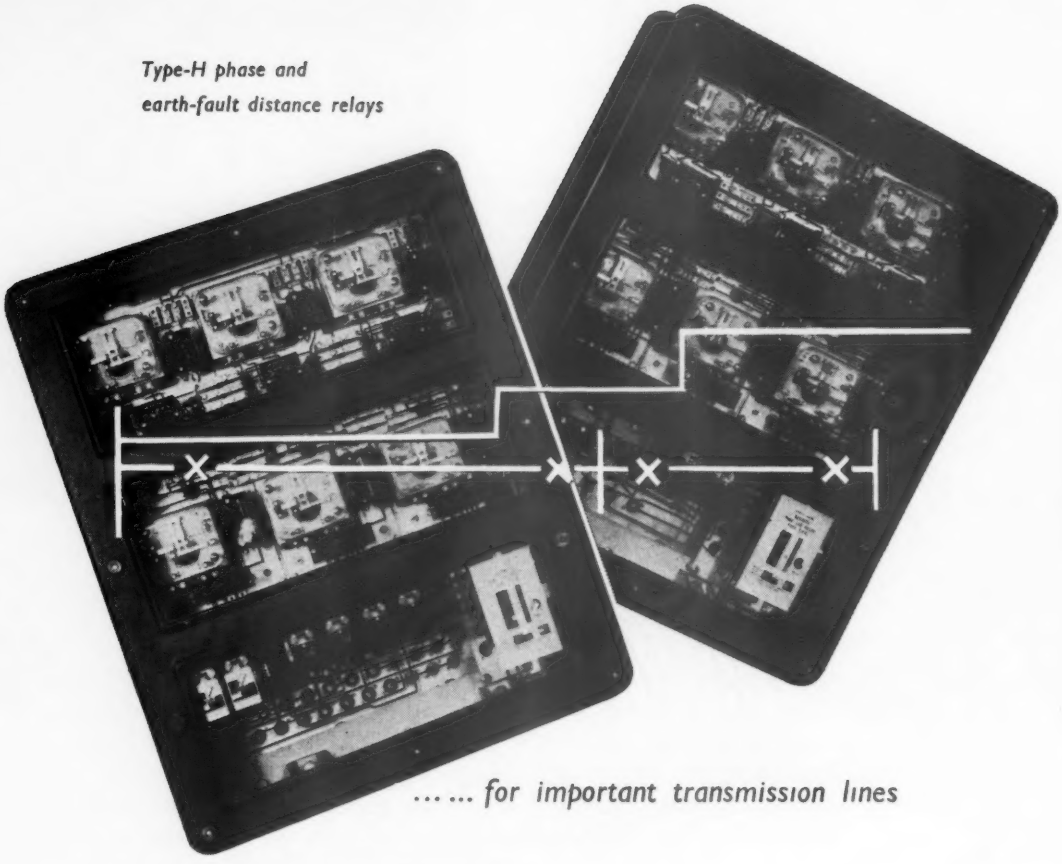
Miniature (moulded case) circuit breakers in single pole, double pole, and triple pole and neutral patterns up to 60 amp. Earth-leakage circuit breakers in double pole, and triple pole and neutral patterns up to 60 amp. Distribution boards.

Wiring Accessories

Type AC and AC/DC tumbler switches of all types. Ceiling and suspension switches. 13 amp. socket-outlets and other ring-circuit wiring accessories. 2, 5 and 15 amp. socket-outlets. Plugs of all types. Ceiling roses, lampholders and bell pushes. Industrial wiring accessories.

Control Equipment

Type-H phase and earth-fault distance relays



..... *for important transmission lines*

DISTANCE-PROTECTION

Reyrolle type-H high-performance distance protection incorporates the following important features:

- High speed for all types of fault
- Accurate measurement for exceptionally wide range of source to line impedance
- Negligible over-reach on D.C. transients
- Separate moving-coil elements for earth-faults and phase-faults
- All relay-elements identical and easily removable
- Self-contained design reduces panel wiring
- Built-in phase-selectors for single-phase auto-reclosing if required

Ask for Pamphlet 1297

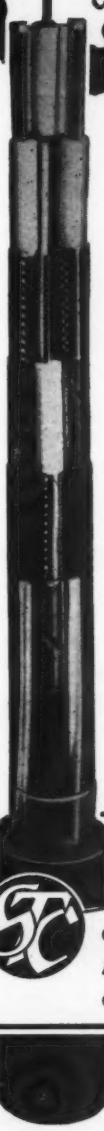
Reyrolle

A. REYROLLE & COMPANY LIMITED - HEBBURN - COUNTY DURHAM - ENGLAND

Over 2,000 conversations on one cable

59. Development of the coaxial cable made a large reduction in the cost of long distance telephone conversations. In modern coaxial cables up to 960 simultaneous conversations can be transmitted over a pair of coaxial tubes, of which there may be several in each cable. But engineering development is now being pushed a stage further. By reducing the spacing between repeater stations from 6 to 3 miles the capacity of existing cables between some main centres will be increased so that the same pair of tubes will cater for about 2,400 simultaneous conversations or 1,000 conversations plus a two-way television channel. Microwave radio systems providing simultaneously for telephony and [illegible] have been developed and brought into service. [illegible] engineers in the Post Office [illegible]

extract from the Post Office Report and Commercial Accounts 1957-58.



S.T.C. were the first in Europe to manufacture Coaxial Cables in 1935 and have pioneered all subsequent developments.

S.T.C. have installed or have on order over 10,000 route miles of Coaxial Cable incorporating 36,000 miles of Coaxial tube.

CABLE AND WIRE GROUP

Standard Telephones and Cables Limited

Registered Office : Connaught House, Aldwych, London, W.C.2

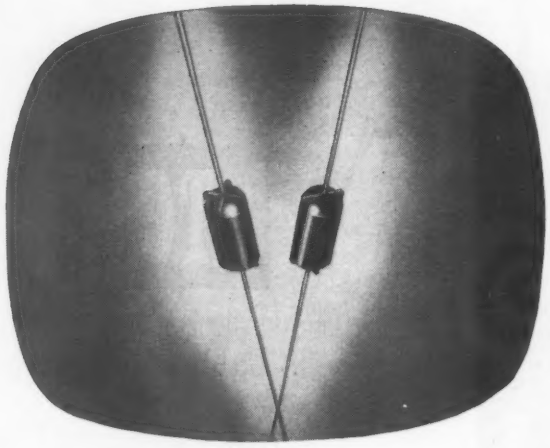
TELEPHONE CABLE DIVISION: NORTH WOOLWICH · LONDON E.16

SenTerCel

SILICON h.t. power rectifier *type FST1/4* for television receivers

The FST1/4 Silicon Power Diode has been specially designed for domestic television receiver H.T. power supplies and is of particular interest to circuit designers planning receivers with 110° scanning, 625 line receivers and colour television receivers. Two diodes may be used in series to provide capacitor smoothed H.T., direct from 250 volts A.C. mains.

SenTerCel FST1/4 silicon rectifiers are miniature wire ended devices which can be speedily mounted to tag panels, no heat sink being required. Typical performance curves and design procedure are included in leaflet MF/109.

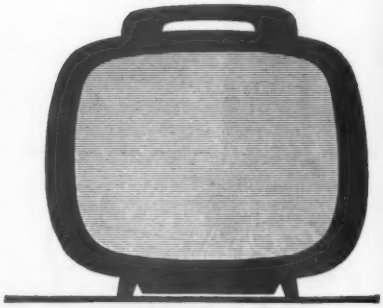


Actual Size

400 VOLTS (P.I.V.)	500 mA UP TO 50°C

Important advantages of the FST1/4 silicon rectifiers are:—

- LARGE POWER OUTPUT FOR SMALL SIZE
- 35 AMPS SURGE CURRENT RATING
- HIGH AMBIENT TEMPERATURE OPERATION
- NO HEAT SINK REQUIRED
- HIGH OUTPUT VOLTAGE
- NO FORWARD AGEING
- HIGH EFFICIENCY
- LOW COST

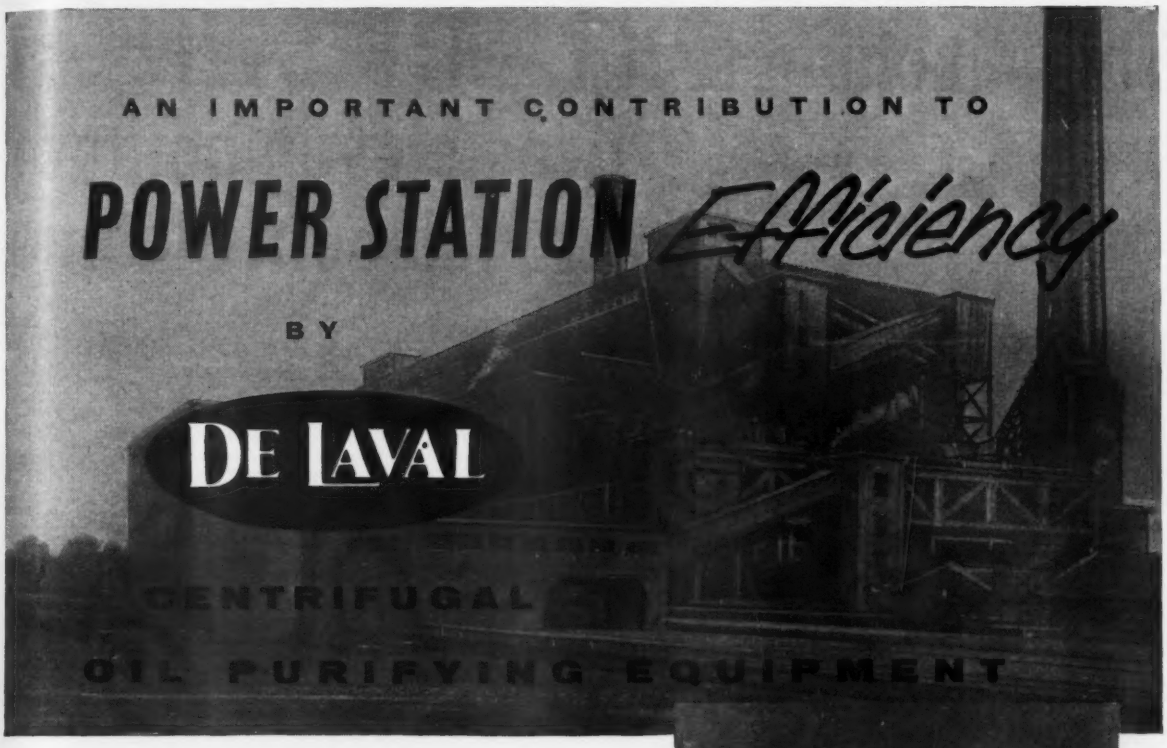


STC COMPONENTS GROUP

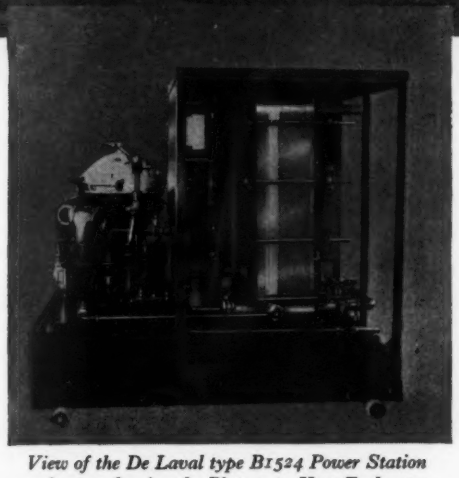
Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

RECTIFIER DIVISION: EDINBURGH WAY · HARLOW · ESSEX



In many power stations today, De Laval centrifuges are employed to maintain lubricating and insulating oils in prime condition. The superior results obtained are due largely to the high, constant separating efficiency of the famous De Laval disc type bowl and the mechanical reliability of the complete De Laval equipments.



View of the De Laval type B1524 Power Station equipment showing the Plate type Heat Exchanger.

DE LAVAL FOR TURBINE LUBRICATING OILS

De Laval turbine lubricating oil purifying equipments are specially designed for continuous by-pass operation, and ensure the maximum continuous removal of water and solid contaminants from the oil with the minimum of attention.

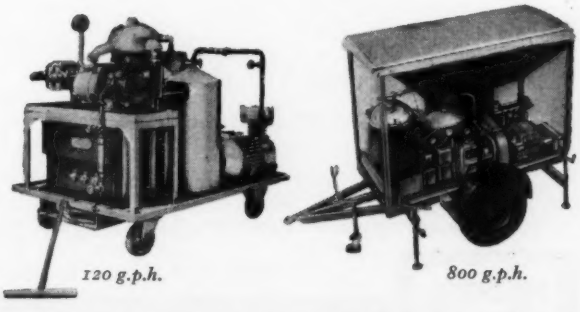
The latest type of De Laval equipment also incorporates a De Laval Plate type Heat Exchanger with regenerative heating section, which reduces the heat loading requirements by at least 60%.

DE LAVAL FOR INSULATING OILS

Many De Laval stationary, portable and roadworthy portable units of the atmospheric and vacuum type have also been supplied in a range of capacities from 10 g.p.h. to 1500 g.p.h. for the most efficient treatment of insulating and switch oils.

These high-efficiency equipments ensure:

- Dielectric strengths well above B.S.S. requirements for new oil.
- Complete extraction of free and dissolved moisture and solids.
- No back pressures or fall-off in throughput capacity.
- No limit to separation of water, sludge or solids.
- Minimum heating of oil.
- Low running costs—no filter aids—simple operation.



120 g.p.h. *800 g.p.h.*

PORTABLE HIGH VACUUM INSULATING OIL PURIFYING EQUIPMENTS

OIL EQUIPMENT DIVISION

ALFA-LAVAL CO. LTD · GREAT WEST ROAD · BRENTFORD · MIDDX · TEL: ISLEWORTH 1221

Smees's D.L. 423

This machine tool LIMIT SWITCH gives eleven contact arrangements in one

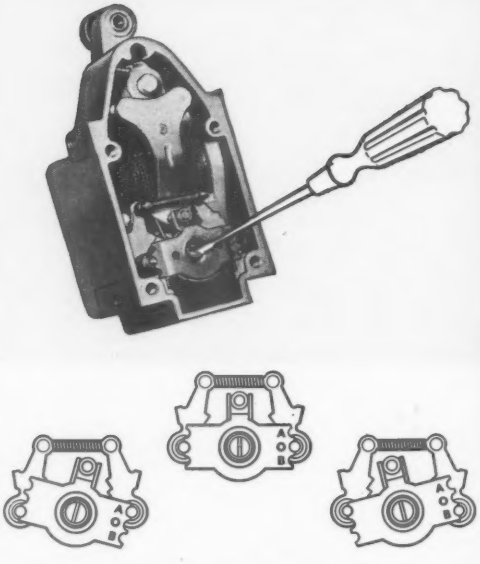
Class 9007, Type T limit switches are heavy duty, oil-tight, quick make and break devices specifically designed for machine tool applications.

Versatile

Simple adjustment of return spring positioning plate determines position of the moveable contact when switch lever arm is in the "free" position. Equally simple adjustment of latches gives single or double step action. Removal of latches or return spring gives additional operating sequences.

11 switches . . . in 1 . . . all you need is a screwdriver!

Operating lever arm position is continuously adjustable and provides up to 80° overtravel. An outstanding Square D design feature.



Simplified Stocking

Many different types of lever arms and base plates are available. Lever arms are separately packed in easily identifiable cartons—and the baseplates are interchangeable. Combined with a relatively small stock of basic switches, the result is simplified stocking to cover a wide range of requirements.

Leaders in Control Gear for over 50 years

To have the best *Specify* Square D

Square D products are stocked by leading electrical wholesalers throughout Great Britain

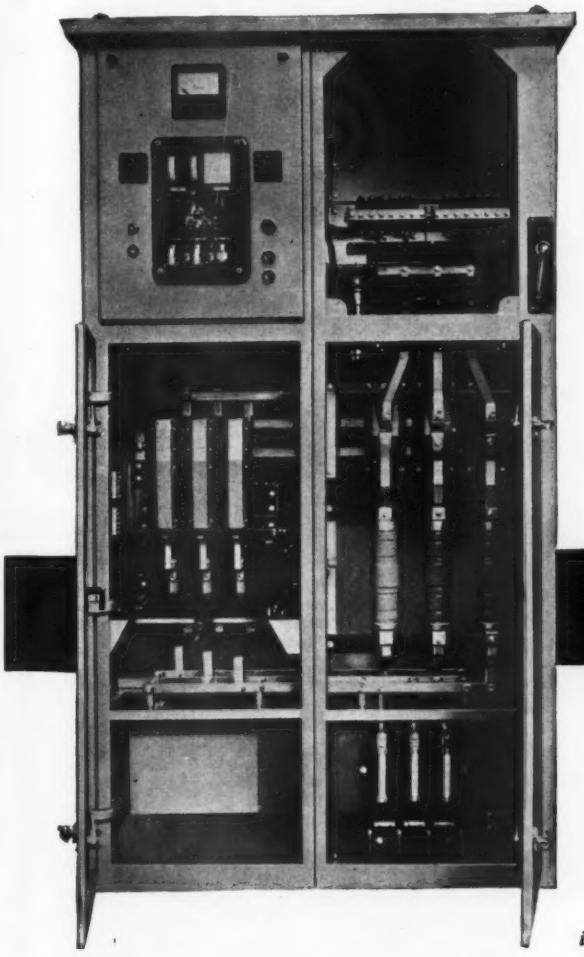
FIELD OFFICES — LONDON · BIRMINGHAM · MANCHESTER · GLASGOW · NEWCASTLE · BRISTOL

SQUARE D LIMITED

CHENEY MANOR, SWINDON, WILTSHIRE

SD45

THE BELMOS 3·3 kV AIR-BREAK CONTACTOR STARTER



Rigorously tested in the Company's own research laboratory, the type K contactor starter is the latest product of the Belmos development team and continues the well-established Belmos tradition of good design and reliability. Suitable for the direct-on-line starting of 3·3 kV motors up to 600 h.p., it can be housed in a free-standing pillar or grouped with similar units to form a switchboard.

- ★ Air-break contactor rated at 150 amperes. Breaking capacity of 1,300 amperes at 3·3 kV, 0·25 power factor.
- ★ d.c. operating magnet supplied from 3,300/110 volt transformer within the pillar.
- ★ Reversing or Earthing isolator, mechanically and electrically interlocked, with 12 auxiliary switches, a.c. or d.c.
- ★ Busbars designed to withstand 150 MVA for 3 seconds.
- ★ Optional earth leakage protection.
- ★ Comprehensive control arrangements, local and remote, with sequence interlocking and automatic sequence starting.
- ★ Provision for auxiliary services, such as brake protection, local lighting, etc.

the type K starter is fully described and illustrated in leaflet J 240 which is available on request.

Belmos

the Belmos company limited

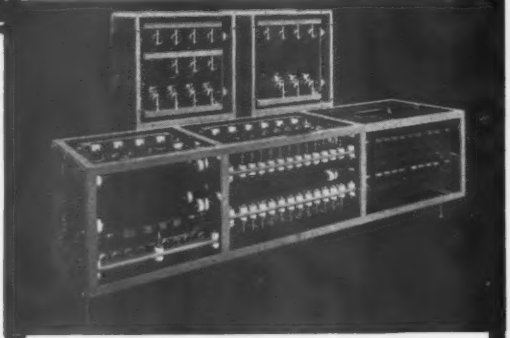
BELLSHILL · LANARKSHIRE

LONDON GLASGOW BIRMINGHAM NEWCASTLE MANCHESTER SHEFFIELD CARDIFF

A Composite Resistor From a Single Resource

80 of the new Brush "Type 2" diesel-electric locomotive will help to change the face and pace of British Railways by the end of 1959. 20 are of 1250 H.P. with a maximum of 75 m.p.h. The later models will be of 1365 H.P. with a maximum of 90 m.p.h.

For their new diesel-electric locomotive, the Traction Division of Brush Electrical Engineering Co. Ltd., were able to order a composite regulating resistor from a single source. Expamet-Cressall alone possessed the facilities to supply resistors incorporating such widely differing elements within their own resources.
The same spirit of co-operation in which Expamet-Cressall entered every stage of this highly successful project is readily at the service of electrical engineers through every branch of Industry.



This is the Expamet-Cressall regulating resistor which controls the power of the AIA-AIA. Robust, accurate aluminium tubular wire-wound resistors are combined with "Expamet" expanded metal elements which together dissipate energy with great efficiency throughout an extremely long life.

Expamet Cressall

The Electrical Division of The Expanded Metal Company Ltd.

London Office: Burwood House, Caxton St., London S.W.1. *Telephone:* ABBey 7766. *Works:* Stranton Works, West Hartlepool; *Telephone:* Hartlepools 5531. The Cressall Manufacturing Company Ltd., Eclipse Works, Tower St., Birmingham 19. *Telephone:* Aston Cross 2666.

Expamet and Cressall
go together all the way

Products of BRITISH DRIVER-HARRIS

No. 1 Nichrome* V, Nichrome,* Chromax*

Of the products we make, the Nichrome series of alloys is pre-eminent. The name Nichrome is registered as a Driver-Harris trade mark in some sixty countries. It is accredited the world's standard of quality for electrical resistance heating.

Nichrome V and Nichrome (the two alloys in most demand today) were not perfected overnight. They have been developed over generations. We take care that this hard-won knowledge is worthily supported in the process of manufacture. At every stage quality is severely controlled and checked. The key craftsmen have many years' experience, and they have the use of impeccable equipment.

Nichrome* V is a nickel-chromium alloy of the 80/20 type. It is used for high temperature resistance heating applications at temperatures up to 1150°C. For resistor elements in such as electric furnaces, domestic cookers and fires it is ideal. It can be supplied in wire, hot and cold rolled strip, hot rolled rounds, and ribbon form. It is also available in superfine sizes— ·002 in. (0·05 mm.) downwards for applications like precision resistors in electronic equipment, and where high ohmic value is necessary.

Nichrome* is a nickel-chromium alloy of the 65/15 type. It is the accepted material for heating elements operating at temperatures up to 950°C, including all types of domestic appliances in this temperature range. It is also used for rheostat and resistance units. It makes for compact units capable of withstanding severe overloads and short circuits without damage or impairing circuits. It resists corrosion and has many non-electrical applications. It is available in the forms of wire, hot and cold rolled strip, hot rolled rounds, and ribbon. Also in superfine wire sizes.

Chromax* This alloy has the nominal composition 37% nickel, 18% chromium, balance iron. It has been developed for use in furnace elements, and particularly for carburising atmospheres.

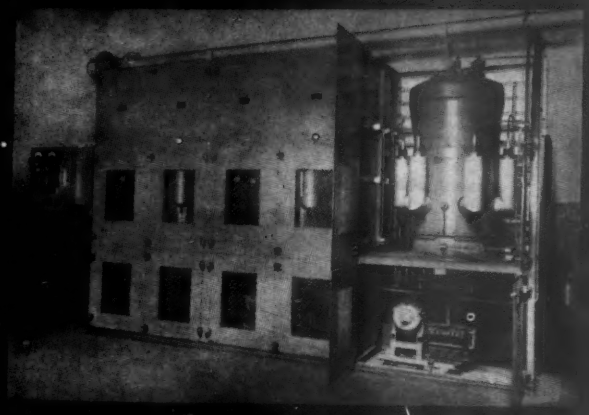
For further information write for Data Sheet No. 5—a 24-page booklet containing comprehensive technical information.

*REGD. TRADE MARK

BRITISH DRIVER-HARRIS CO LTD

NICHROME REGD TRADE MARK

Cheadle Heath, Stockport, Cheshire

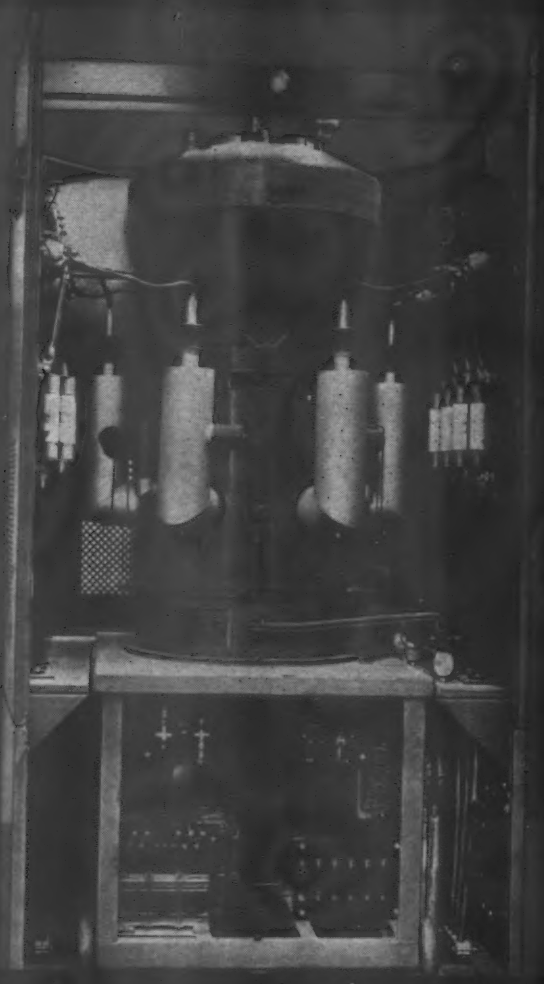


1000

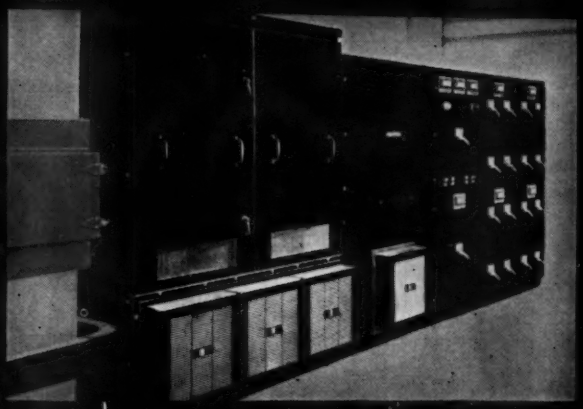
600 kW, 230/240 V, 3-cylinder pumpless air-cooled steel tank rectifier installation at a British steelworks.

300 kW, 550 V rectifier in Western Australia. The first of its kind installed underground, 300 ft. below, in Australasia.

A 100 kW, 225 V, G.E.C. grid-controlled pumpless air-cooled steel tank rectifier equipment undergoing "inclining tests". This equipment formed part of a comprehensive contract for a large floating dock for the Admiralty, for which the G.E.C. acted as main machinery contractor. The rectifiers have to function perfectly under the conditions illustrated.



1224 kW mobile rectifier and substation specially designed for service with the Netherlands Railways.



Single anode air-cooled steel tank, grid controlled rectifiers controlling 220 kW driving equipment for high-speed printing press in Capetown.

000 kW

pioneers and world leaders in this field

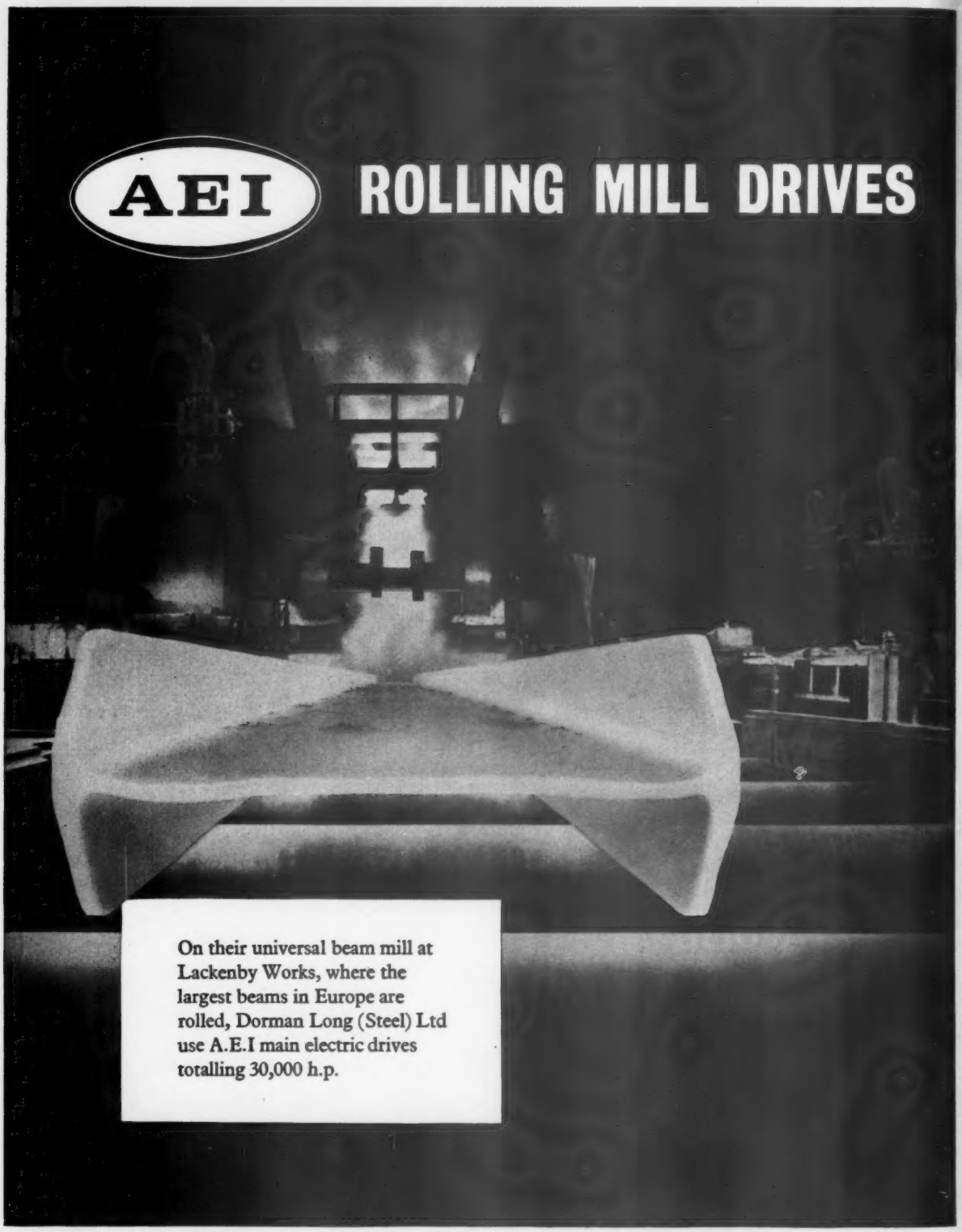
It was less than thirty years ago that G.E.C. pioneered the first water-cooled rectifier of wholly British design. Only five years later G.E.C. produced the world's first pumpless air-cooled steel tank unit.

Today over a million kilowatts of G.E.C. rectifiers are serving a diversity of industries all over the globe . . . operating under every climatic condition, from tropical heat and humidity to polar extremes of cold.

Some operate on a six month continuous full load duty cycle, others intermittently. But wherever they serve, they can be depended upon for that consistent reliability for which G.E.C. rectifiers are renowned.

G.E.C. mercury arc rectifiers

HEAD OFFICE: MAGNET HOUSE, KINGSWAY, LONDON, W.C.2
THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND


AEI
ROLLING MILL DRIVES
On their universal beam mill at Lackenby Works, where the largest beams in Europe are rolled, Dorman Long (Steel) Ltd use A.E.I main electric drives totalling 30,000 h.p.

ASSOCIATED ELECTRICAL INDUSTRIES LIMITED

HEAVY PLANT DIVISION

RUGBY AND MANCHESTER, ENGLAND

A5376

P.M.A.

Leadership

SERVING A CHANGING WORLD

Almost every technical advance brings with it requirements for yet more PMA permanent magnets: radar, television, automatic train control, factory automation and nuclear power stations are but examples. PMA members collaborate in the design, taking full advantage of the ever-greater range of materials developed by the PMA Central Research Laboratories.

CAST SINTERED CERAMIC and FORGED MAGNETS

ALCOMAX II – COLUMAX
ALCOMAX III
SEMI-COLUMNAR ALCOMAX
COBALT STEELS
ALCOMAX IV
HYCOMAX
ALNI
ALNICO
TUNGSTEN STEELS
FEROBA

PMA

PERMANENT MAGNET ASSOCIATION

Pioneers and Leaders in Permanent Magnet Materials

SHEFFIELD

More protection for hands and machines

TRIUMPHS OF SHELL RESEARCH

New Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, the Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

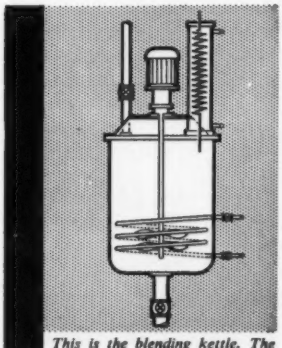
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors to produce the right oil for the job. If you and your organization have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

NEW SHELL DROMUS SOLUBLE CUTTING OILS

another proof of Shell leadership in lubrication

SILICON

MULLARD GENERAL PURPOSE SILICON ALLOY TRANSISTORS ...THE FIRST THREE TYPES

Transistor OC203, the most recent of the first three types in the Mullard series of 50 mA general purpose silicon alloy transistors, is now fully available. This new transistor has a collector hold-off voltage of —60V and is intended for high voltage applications.

Like the OC200 and OC201 announced earlier, the OC203 has a low bottoming voltage and all the advantages of the well-known OC71 germanium series. The equipment design considerations are basically the same for both the silicon and germanium series, and designers can gain the maximum benefit from their experience with germanium when using the silicon transistors.

All three silicon transistors feature a collector leakage current and reduced noise fi Their wide junction temperature range m them suitable for use at low and high tem atures in aircraft, guided weapons and indus equipment.

These silicon 50 mA transistors express Mullard philosophy for both germanium silicon devices . . . thorough develop followed by extremely large scale produ to provide the user with practical and re transistors at very favourable prices.

Your enquiries are invited on the OC200 series and other semiconductor devices in the Mullard range of over sixty types. Please write or telephone the address below.

OC200

The basic type in the series. Average current gain 20 and minimum f_α 0.3 Mc/s. Maximum collector voltage is —25V, but the low bottoming point allows operation from supplies as low as 1.2V.

OC201

A similar transistor to the OC200, but with average current gain increased to 30 and minimum f_α increased to 2 Mc/s.

OC203

This, the most recent transistor in the series, fulfils the requirements of applications needing higher voltage ratings. Maximum collector voltage, d.c. or peak, is —60V.

TYPE No.	OC200	OC201	OC2
Minimum operating ambient temperature (°C)	—50	—50	—5
Maximum junction temperature (°C)	+150	+150	+15
Abridged data (at Tamb 25°C)			
V_{cb} (pk) max. (V)	—25	—25	—4
V_{cb} max. (av or d.c.) (V)	—25	—25	—4
I_c (pk) max. (mA)	50	50	50
I_c max. (mA)	50	50	50
α' (or β) spread	15 to 60	20 to 80	10 to
V_{ce} (I_c=7 mA, I_b=1mA) (mV)	—130	—100	—13
$r_{bb'}$ (Ω)	125	125	125

Mullard

MULLARD LIMITED · SEMICONDUCTOR DIVISION · MULLARD HOUSE · TORRINGTON PLACE · LONDON WC1 · TEL: LANGHAM

SILICON

MULLARD

OC200 SERIES

THE FIRST THREE TYPES ARE NOW

ALL IN LARGE SCALE PRODUCTION

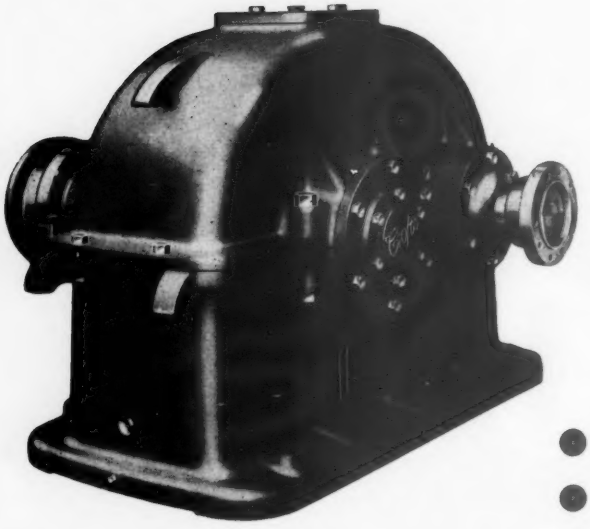
ALL AVAILABLE IMMEDIATELY

Mullard

semiconductor division

MIS 13

Wherever power is used Crofts Gearboxes play a vital role . . . .



CROFTS DOUBLE HELICAL GEAR UNITS

Fractional to 8,000 horsepower
ratios up to 50:1
Send for Publication 535Z2

- **High quality heavy duty reduction gears**
- **Standard and high ratio single reduction units**
- **Double reduction units with coaxial input and output shafts**
- **Special units for larger powers, or with special gear combinations, made to order**

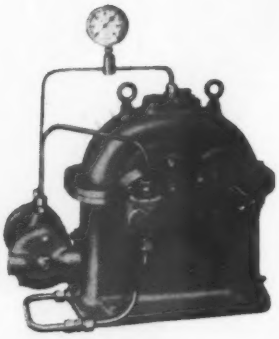
ALSO:

"FREE-SPACE" TYPE HYDRAULIC COUPLINGS AND DRIVES

Up to 350 h.p. Dual types up to 700 h.p. Publication 5951Z2

MEDIUM POWER TURBINE GEARS

Powers up to 500 h.p. Input speeds up to 4,500 r.p.m. Ratios up to 10:1 Publication 5327Z2



CROFTS (ENGINEERS) LIMITED

POWER TRANSMISSION ENGINEERS

THORNBURY · BRADFORD 3 · YORKSHIRE

Phone: 65251 (20 lines) **Telegrams: 'Crofters Bradford Telex'** **Telex 51186**

Branches at:
Belfast, Birmingham, Bristol, Cardiff, Dublin, Glasgow, Ipswich, Leeds, Liverpool, London, Manchester, Newcastle, Northampton, Nottingham, Sheffield, Stoke-on-Trent. Subsidiary Companies in CANADA, SOUTH AFRICA, U.S.A.

WORLD-WIDE REPRESENTATION

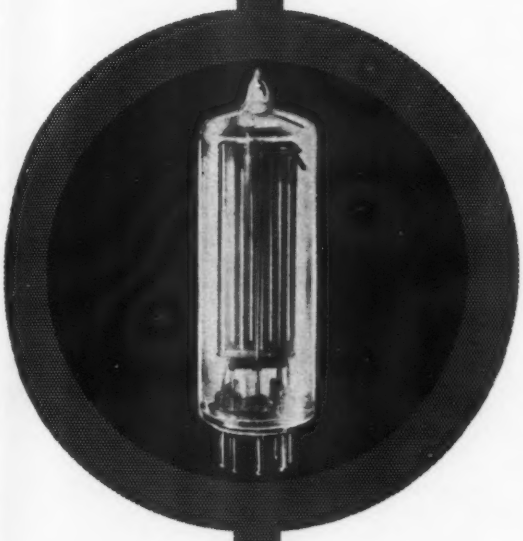
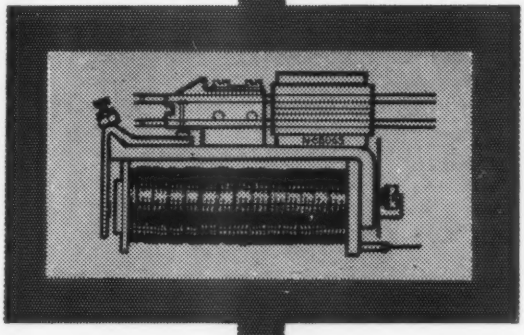


Photo-electric control...

the simplest system

There is no form of photo-electric control simpler, easier, cheaper than that with cadmium sulphide cells. Nothing more is required than a photocell, a relay and the power source. If you are designing photo-electric control equipment, or are interested in any way, you cannot afford to be without full information. Write to Mullard for details of photocells ORP11 and ORP90.

SUPPLY VOLTAGE



Photocells

ORP11 & ORP90

- **Sensitive** No amplifiers needed.
- **High Current** Robust relays operated direct.
- **Non-Polar** Operation from d.c. or a.c. supplies.
- **Wide Response** Through entire visible spectrum to near infra-red.
- **Low Dark Current** Typical light to dark current ratio 10,000 to 1.
- **Wide Range of Applications** Flame failure detection, door opening, automatic lighting control, and industrial on/off control are only a few of the many possible applications.

Mullard Limited

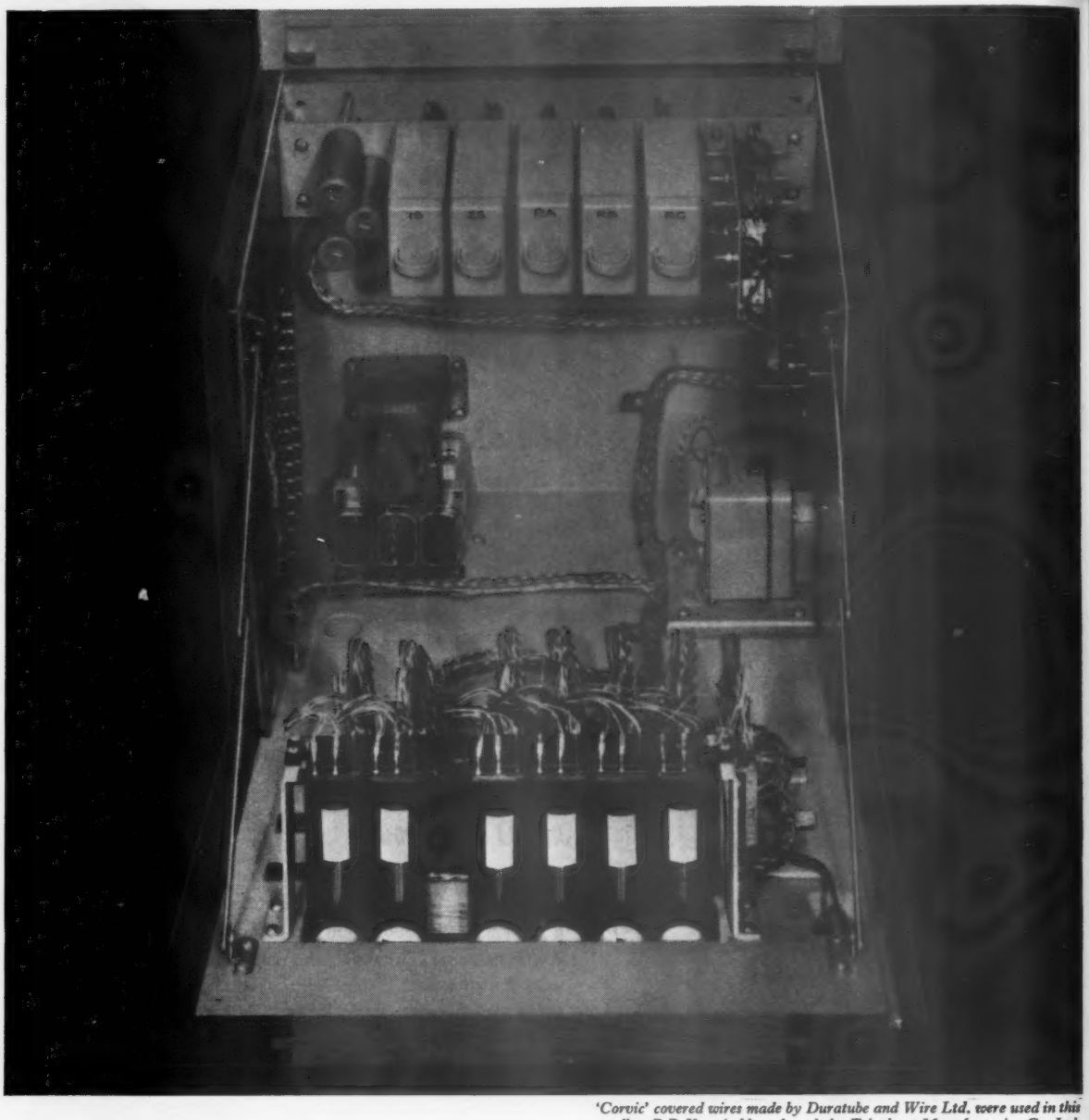
Mullard House, Torrington Place, London, W.C.1

Telephone: LANgham 6633

Mullard

GOVERNMENT AND INDUSTRIAL VALVE DIVISION

MVT 368a



'Corvic' covered wires made by Duratube and Wire Ltd. were used in this cordless P.B.X. switchboard made by Telephone Manufacturing Co. Ltd.

When wires for switchboards are to be covered with p.v.c.

make sure they're covered with 'Corvic'

'Corvic' is backed by the finest research and technical service in the country. When you use 'Corvic' or even if you are simply considering its use, I.C.I. put their service at your disposal.

One particularly valuable application of 'Corvic' is in the insulation of wires and cables. Illustrated is a cordless P.B.X. switchboard made by Telephone Manufacturing Co. Ltd. using uni-, bi- and tri-coloured insulated wires made by Duratube and Wire Ltd. who use 'Corvic'.

'CORVIC'

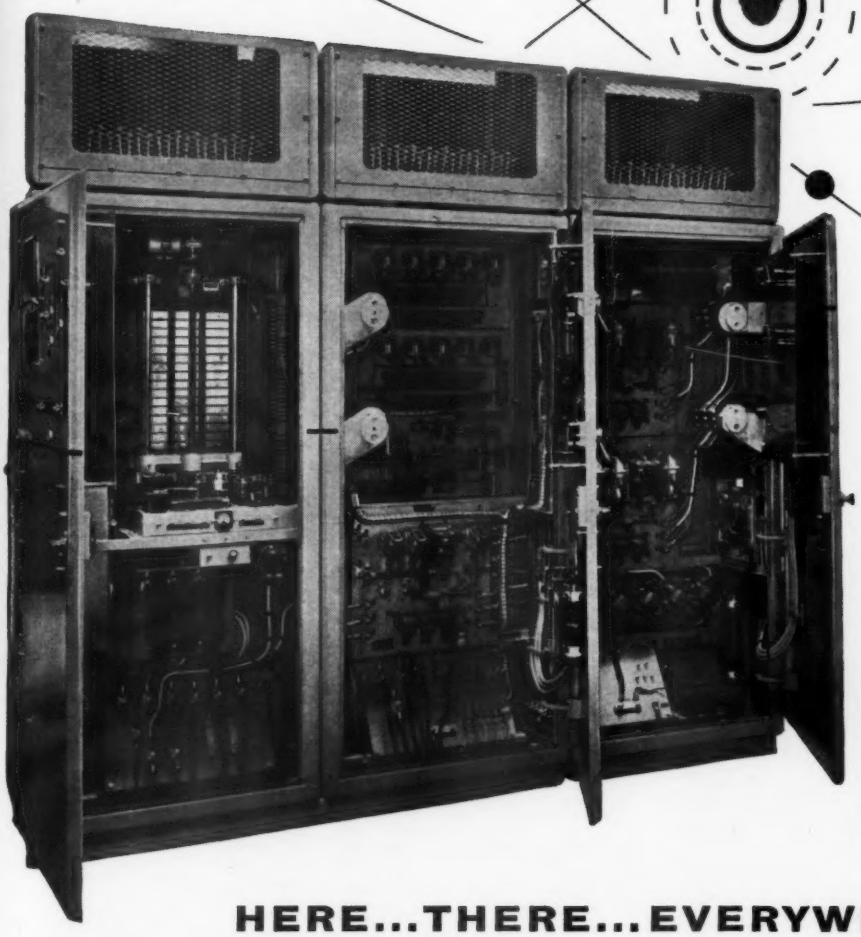
'Corvic' is the registered trade mark for the p.v.c. polymers manufactured by I.C.I.

IMPERIAL CHEMICAL INDUSTRIES LIMITED • LONDON • S.W.1

ICI

PC. 23

PELAPONE for control



Pelapone, backed by long experience in Automatic Rotating Plant, are able to offer Control Systems of high accuracy to meet specific requirements. Integrated Control Systems can be designed to cater for a wide range of inter-dependent Plant including mimic diagrams and remote indication units.

HERE...THERE...EVERYWHERE

PELAPONE ENGINES LIMITED

Sales Division: 38/40 Bruton Street, London W.1.
Cables: "Pelapone-London." Telephone: MAYFAIR 2034.

Works: Slack Lane, Derby.
Grams: "Pelapone-Derby." Telephone: DERBY 45436.

©A257

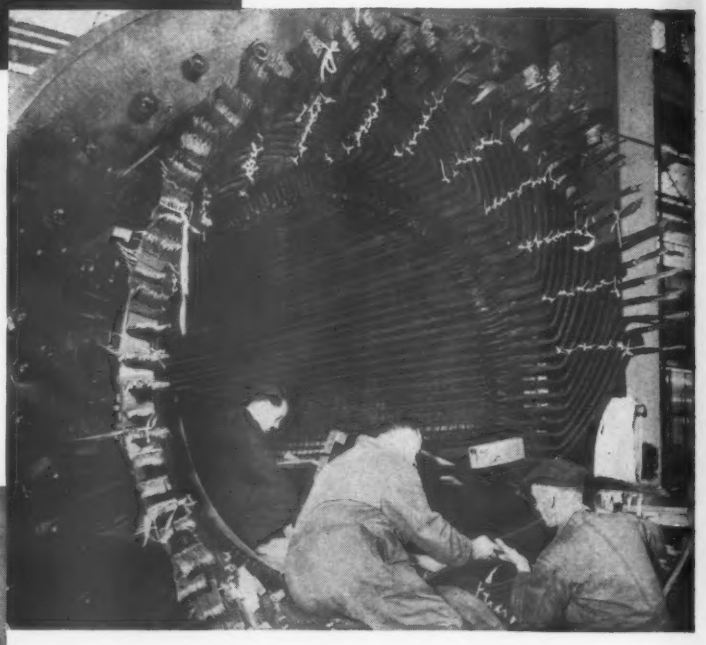
MS

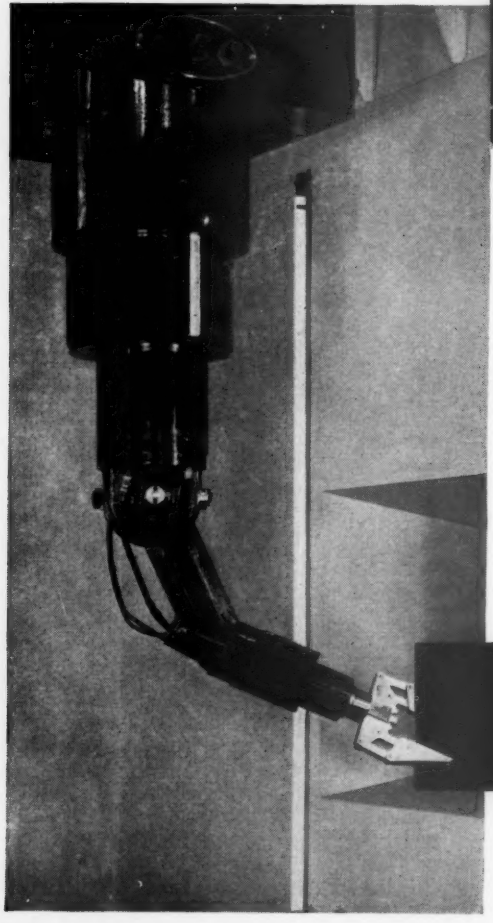
Silicone insulation gives increased reliability

Silicones insulate turbo-generators

Long life and reliability are desirable in all types of electrical equipment but especially in high capital cost plant such as turbo-generators. Silicone varnished, glass covered conductors are used for the stator windings of turbo-generators built by C. A. Parsons & Co Ltd
The photograph shows the windings of an inner stator core of a 100 MW hydrogen-cooled turbo-generator which is one of the units in a 200 MW cross-compound set, the first of four which will be supplied to Canada.

Photo by courtesy of C. A. Parsons & Co Ltd





Silicones lend a hand!

This General Electric Co Ltd remote control power manipulator – believed to be the first of its kind to be designed and produced in Europe – has been developed to handle toxic or radioactive materials in nuclear energy establishments. It is the mechanical counterpart of a human hand and arm and will perform delicate operations or lift heavy loads with equal ease. The conditions under which this equipment is required to operate demand complete reliability, ease of maintenance and the longest possible life under the effects of gamma radiation. Silicone insulation was specified to meet these exacting demands and is used for the stator windings of the induction motors which power the motions and also for the electro-magnetic brake coils on the larger motors.

Midland Silicones Ltd manufacture in Great Britain a full range of silicone products for use in the electrical industry.

Photo by courtesy of General Electric Co. Ltd.

MIDLAND SILICONES LTD

(Associated with Albright & Wilson Ltd, & Dow Corning Corporation)

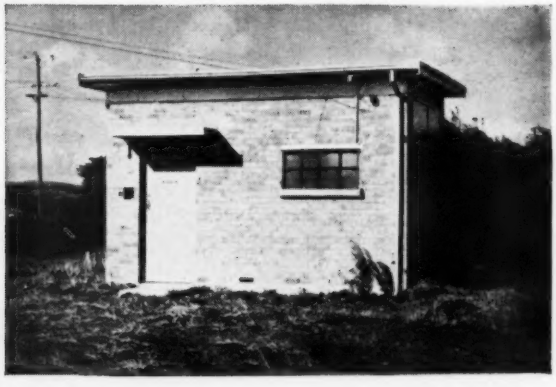
first *in British Silicones*

68 KNIGHTSBRIDGE · LONDON · SW1 · TEL: KNIGHTSBRIDGE 7801
Area Sales Offices: Birmingham, Glasgow, Leeds, London, Manchester
Agents in many countries

TSW/MS130

THIS COMPACT UNIT

supersedes this repeater building and its contents



A.T.E COAXIAL SYSTEM TYPE C300A

for use on small core coaxial cables

A system in the CM range of transmission equipment

- Fully transistorised
- Suitable for national or international networks
- Designed for routes of medium circuit capacity
- Compact—power fed-repeaters
- Easy Maintenance

For further details write for bulletin TEB 3202

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD.

STROWGER HOUSE, ARUNDEL STREET, LONDON W.C.2. Tele: TEMple Bar 9262. Telegrams: Strowger, Estrand, London AT 8871

a place in the Hall of Fame

What is special about Harland Ulectriglide submersible pumpsets.

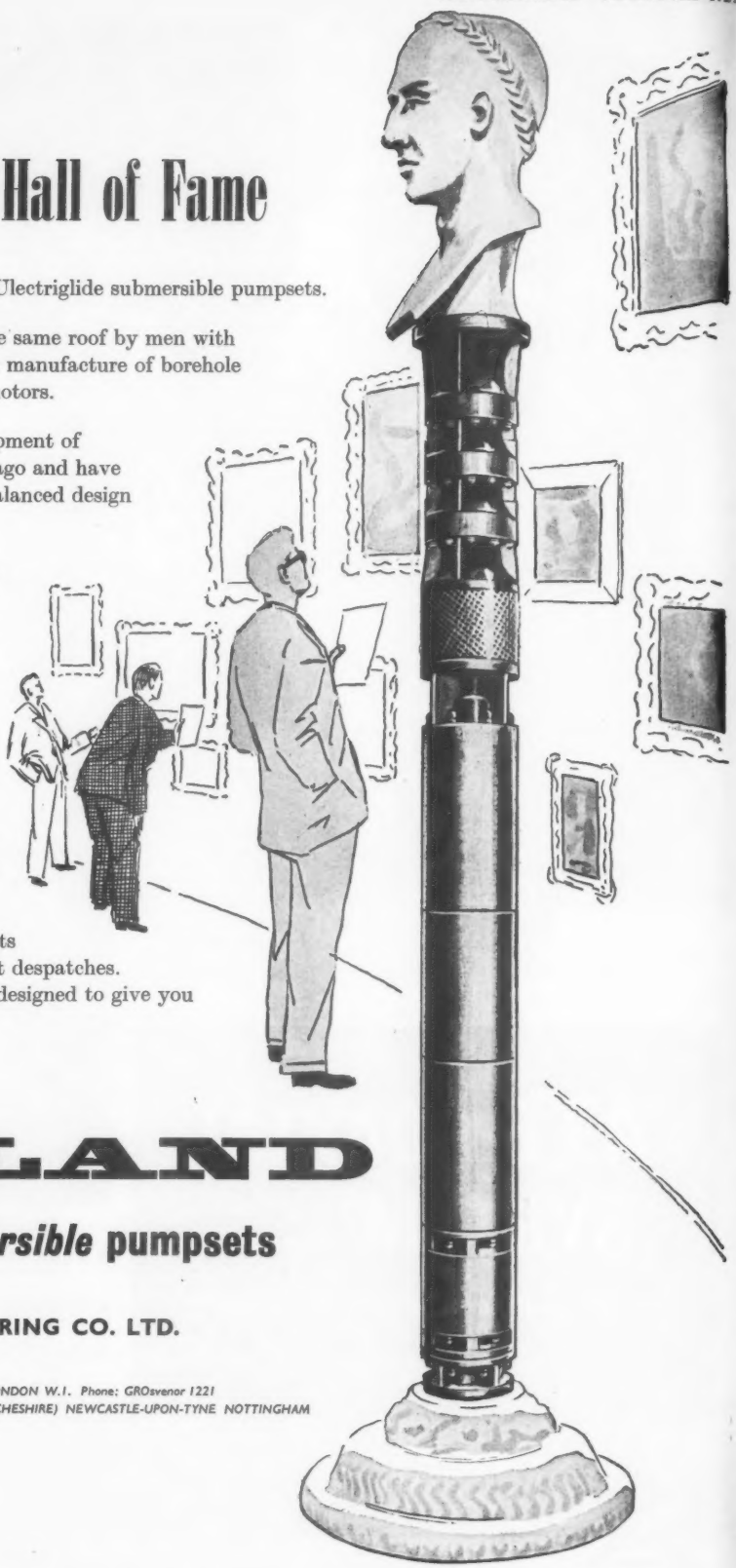
Pump and motor built under the same roof by men with over 50 years' experience on the manufacture of borehole pumps and associated electric motors.

Harland commenced the development of submersible pumpsets 25 years ago and have gained wide experience in the balanced design of the two components.

The Harland submersible motor is of the all wet type and is therefore easy to maintain and overhaul as it does not rely on special seals between rotating and stationary parts.

A special study has been given to the design of journal and thrust bearings which form the most important part of any machine operating under water.

Harland offer standard Ulectriglide submersible pumpsets from 20 to 130 h.p. against short despatches. An after sales service scheme is designed to give you complete satisfaction.



HARLAND

***ulectriglide submersible* pumpsets**

THE HARLAND ENGINEERING CO. LTD.

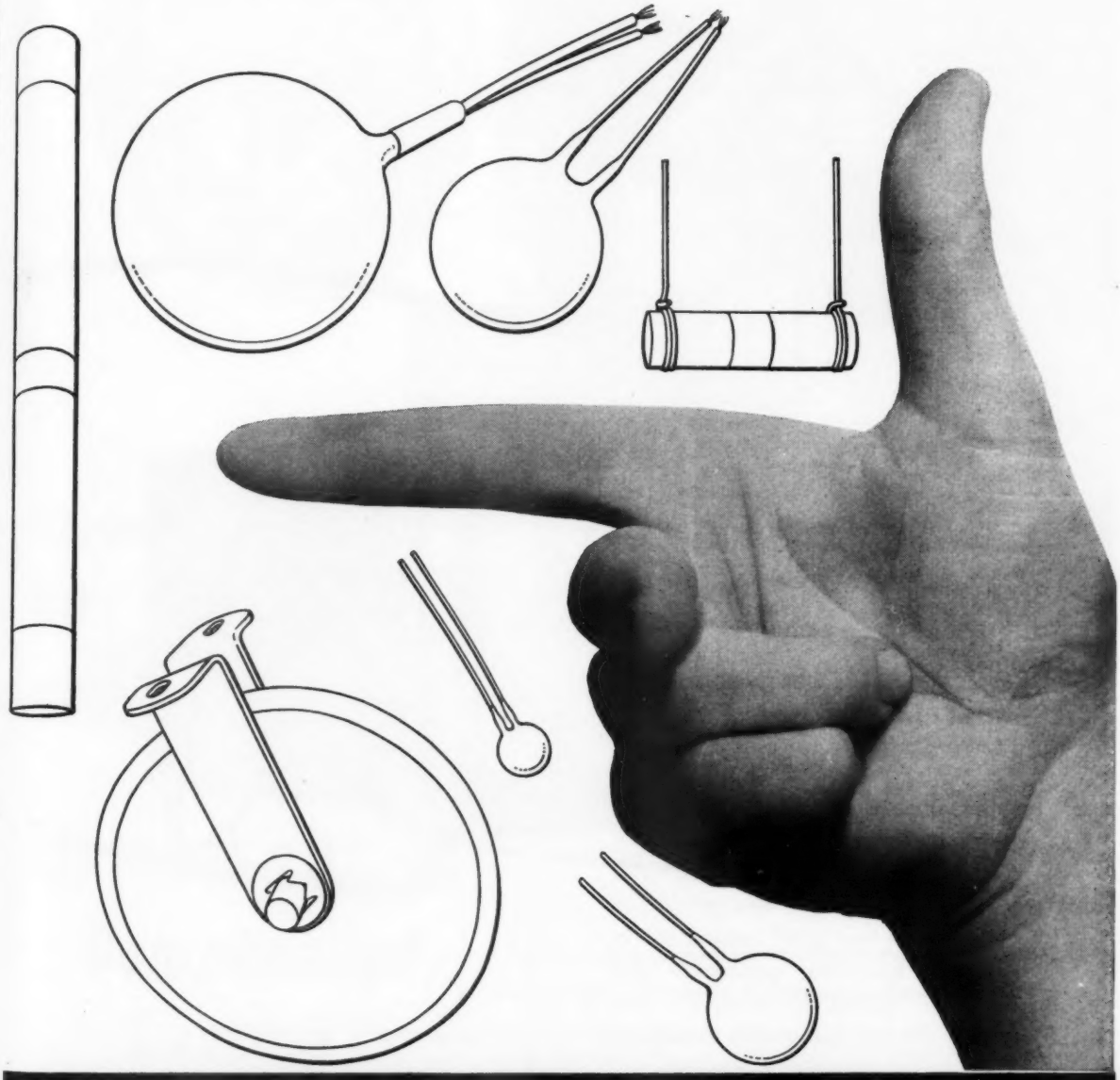
ALLOA SCOTLAND

London Office: HARLAND HOUSE 20 PARK STREET LONDON W.1. Phone: GROsvenor 1221
Branches: BRISTOL GLASGOW LEEDS TIMPERLEY (CHESHIRE) NEWCASTLE-UPON-TYNE NOTTINGHAM WOLVERHAMPTON AND OVERSEAS.

A191/11 P.169

DEFEAT LENZ'S LAW by using MORGANOHM

Voltage Sensitive Resistors— the electronic safety valve



Further information may be obtained from :

THE MORGAN CRUCIBLE COMPANY LIMITED

'Y' DEPARTMENT, NORTON WORKS, WOODBURY LANE, NORTON, WORCESTER

Telephone: WORCESTER 66912 *Telegrams:* CRUCIBLE, WORCESTER

Y53A

RECORD Graphic Recorder

with clip-on transformer

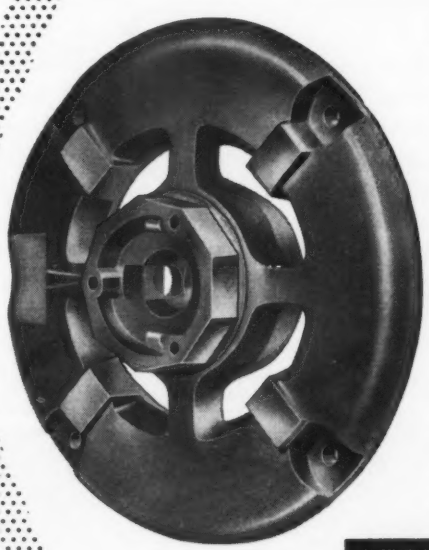
The combination shown provides 7 current ranges up to 600A.

In addition the Recorder is provided with self-contained voltage ranges of 150, 300 and 600V. The whole forms an easily transportable Universal A.C. Recorder which is accurate, responsive and robust. Send for details.

THE RECORD ELECTRICAL COMPANY LIMITED

"CIRSCALE WORKS" · BROADHEATH · ALTRINCHAM · CHESHIRE

C1918



CROMPTON PARKINSON AGREE...

there is no end... to SHAW

EFFICIENCY *in Complicated Casting!*

The intricate aluminium pressure diecastings illustrated above (by courtesy of Messrs. Crompton Parkinson) were made for them by ARTHUR SHAW & CO. LTD., and are the endshields for an electric motor.

Although necessarily a complicated job for SHAW, this is yet another striking example of how costly machining can be avoided by the use of diecasting. Why not review your own machining costs and problems and call us in for advice? Without obligation of course!

ARTHUR SHAW & COMPANY LIMITED.

incorporating the Shaw Foundry Co.

WILLENHALL · STAFFS.

THEY SET A STANDARD

OVER 1500 years ago the Romans built the roads whose names are still familiar to us—Fosse Way, Watling Street, Icknield Way, Ermine Street and many others. Often following tracks old before the Romans came, these broad, straight roads provided vital communication for the legions, and for the administrators and merchants who followed in their steps. In road building, as in many other fields, the Romans set a standard which few have equalled since.

In cable making, too, standards are of vital importance.

For over 100 years members of the Cable Makers Association have been concerned in all major advances in cable making. Together they spend over one million pounds a year on research and development. The knowledge gained is available to all members. This co-operation has contributed largely to the world-wide prestige that C.M.A. cables enjoy, and it has put Britain at the head of the world cable exporters.

Technical information and advice is freely available from any C.M.A. member.

Roman legionaries on the march.

MEMBERS OF THE C.M.A.

British Insulated Callender's Cables Ltd · Connollys (Blackley) Ltd. Enfield Cables Ltd · W. T. Glover & Co. Ltd · Greengate & Irwell Rubber Co. Ltd · W. T. Henley's Telegraph Works Co. Ltd · Johnson & Phillips Ltd · The Liverpool Electric Cable Co. Ltd · Metropolitan Electric Cable & Construction Co. Ltd. Pirelli-General Cable Works Ltd. (The General Electric Co. Ltd.) St. Helens Cable & Rubber Co. Ltd · Siemens Edison Swan Ltd. Standard Telephones & Cables Ltd · The Telegraph Construction & Maintenance Co. Ltd.

Insist on a cable with the C.M.A. label

The Roman Warrior and the letters 'C.M.A.' are British Registered Certification Trade Marks.

CABLE MAKERS ASSOCIATION

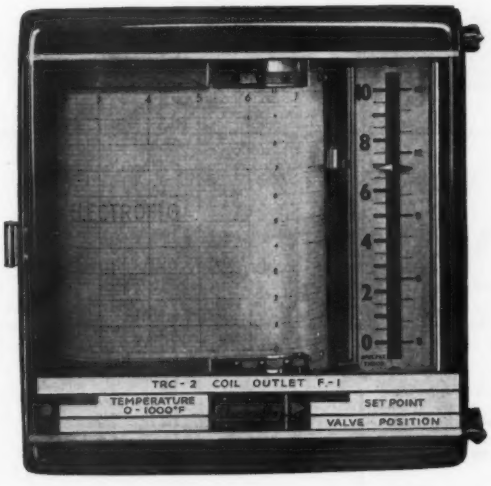
CABLE MAKERS ASSOCIATION, 52-54 HIGH HOLBORN, LONDON, W.C.1. TELEPHONE: HOLBORN 7633
CMA 23

Electroflo
Meters & Controls

Series 199

4" strip chart MINIATURE ELECTRONIC RECORDING POTENTIOMETER

- Identical panel cut-out ($6\frac{3}{8}$" x $6\frac{5}{8}$") and appearance as Electroflo Series 361 Pneumatic Recorders and Recording Control Stations.
- Potentiometric and Pneumatic Recorders can now be grouped logically on panel for "miniature presentation" without degrading electrical signals to pneumatic signals before recording.
- 5 mV. full-scale deflection. Resolution 1:1000. Continuous standardisation with manual checking facilities on panel instrument. Amplifier(s) rack mounted separately behind panel.



Panel instrument of Model 199 21/1/S/C with Chassis withdrawn.

- Available as Single or Two Pen Recorder with electrical re-transmission or as Single Pen Recorder with electrical re-transmission, air sender, full pneumatic control station facilities and rear mounted pneumatic controller.

Electroflo METERS COMPANY LIMITED LONDON N.W.10

Head Office: Abbey Road, Park Royal, N.W.10 Telephone: Elgar 7641/8. Telegrams & Cables: Elflometa, London, Telex. Telex No. 2-3196 Factories: Standard Road, Abbey Road & Minerva Works, Park Royal & Maryport Cumberland. Agents in all principal countries throughout the world. Member of Elliott-Automation Group

Semiconductors

COMPUTER TRANSISTORS

The Semiconductors range of Computer Transistors, designed and tested to the special requirements of computer engineers, is the key to a new order of computer speed and reliability. Overall reliability is further increased by making possible a substantial reduction in the number of associated components.

The two types of Silicon Alloy Transistor shortly going into production will make it possible to extend this high-speed computer performance into **ambient** temperatures well above 100°C. **Samples are available now.**

	TYPE	DESCRIPTION	RISE TIME millimicroseconds	Vc max	Ic max
HIGH-SPEED LOW-LEVEL SWITCHING GERMANIUM	SB 344 SB 345	General purpose transistors for conventional logic circuits.	50	5v	5mA
	SB 240	Designed for directly coupled circuits. Controlled input, saturation and hole storage characteristics.	30	6v	15mA
	MA 393	High gain transistor for high-speed driving of parallel circuits.	30	6v	50mA
	2N 501	Ultra-high speed transistor with controlled input and saturation characteristics.	10	12v	50mA
HIGH-SPEED LOW-LEVEL SWITCHING SILICON	SA 495	General purpose 10Mc/s transistor for conventional logic circuits.	100	25v	50mA
	SA 496	15Mc/s transistor for directly coupled circuits. Saturation resistance typically 10 ohms. Controlled input and hole storage characteristics.	80	10v	50mA
CORE DRIVING GERMANIUM	2 N 597	min $f\alpha$ 3Mc/s	250 mW high frequency alloy transistors with high gain and low saturation resistance	400 *	20v	400mA
	2 N 598	min $f\alpha$ 5Mc/s		250 *	20v	400mA
	2 N 599	min $f\alpha$ 12Mc/s		100 *	20v	400mA
	2 N 600	min $f\alpha$ 5Mc/s	750 mW versions of 2 N 598 and 2 N 599. Peak current 3 amps.	250 *	20v	400mA
	2 N 601	min $f\alpha$ 12Mc/s		100 *	20v	400mA

* *rise time to 400mA*

Full technical details and applications assistance available on request.

Semiconductors Limited

CHENEY MANOR
SWINDON · WILTS
TELEPHONE: SWINDON 6421/7

S.C.18

White and Riches Ltd

—specify † WARMS A/C or D/C COMPUTING UNITS AND SYSTEMS
for research, development and production in the fields
of AUTOMATION, AERONAUTICS, MISSILES and SATELLITES
to enable *complex non-linear problems* to be
analogued with these advantages
RELIABILITY, REPEATABILITY, FLEXIBILITY, HIGH RESOLUTION,
FAST RESPONSE and HIGH UTILISATION
The full range of units includes E/M SERVO,
SERVO AMPLIFIER · LINE AMPLIFIER · RESOLVER AMPLIFIER

† *White And Riches Modular Systems*

SERVOS • SYSTEMS • SWITCHES

INERTIA SWITCH LTD

offer a wide range of acceleration-sensitive devices.
SWITCHES · PULSE OUTPUT UNITS · SHOCK INDICATORS · OVERSPEED CONTROLS
GAS RELEASE VALVES · DEVICES DESIGNED TO YOUR SPECIFICATIONS

★ Axial, radial or rotary response. Momentary or holding contacts.
Provision for adjustment or resetting.
★ Wide sensitivity range from ·05g to 500g.
Quick acting or damped to reduce sensitivity to superimposed vibration
★ Stability, accuracy and reliability assured by inherent simplicity of design
and use of high quality materials

Head Office: 121 KINGSWAY, W.C.2 *Telephone* { *White and Riches Ltd:* CHAncery 4037 / *Inertia Switch Ltd:* CHAncery 3759

Works: VICTORIA ROAD, BURGESS HILL, SUSSEX *Telephone:* BURGESS HILL 85661

"Albion" INDUSTRIAL COUNTING INSTRUMENTS AND MEASURING MACHINES

Predetermined Counter will make or break contact on reaching zero. (With reset)

Our comprehensive catalogue will be sent on request, or better still, a technical representative will gladly call on you.

FOR REMOTE OPERATION, ELECTRO-MAGNETIC COUNTER (WITH RESET)—FOR BASE OR PANEL MOUNTING.

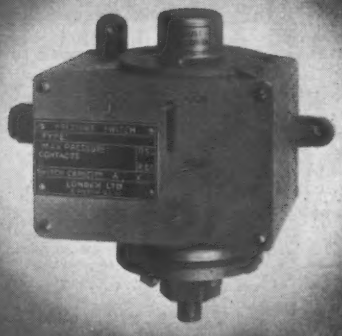
PATENTED IN PRINCIPAL COUNTRIES.

"INSTRUMENT DIVISION"
B. & F. CARTER & CO. LTD.
ALBION WORKS
BOLTON 10
ENGLAND

TEL: BOLTON 4344 ALL LINES
GRAMS: BRAIDERS BOLTON

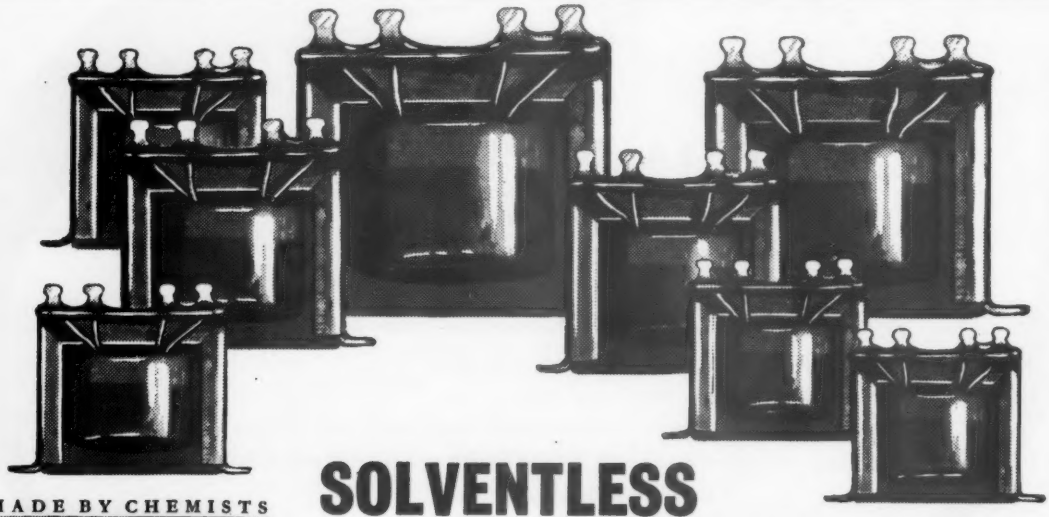
LONDEX *Pressure Switches*

FOR ALARM CIRCUITS



LONDEX LTD LIST ON REQUEST

ANERLEY WORKS, LONDON, S.E.20 ★Sydenham 6258



MADE BY CHEMISTS

Sterling INSULATING VARNISHES

SERVICED BY ENGINEERS

SOLVENTLESS
INSULATING VARNISH

STERLING chemists have produced this solventless insulating varnish with which perfect penetration is assured without recourse to heating. In addition there is extremely low moisture absorption, excellent flexibility and heat ageing, cavitation is minimized and the varnish has a good storage life. STERLING solventless insulating varnish is widely used on transformers, field coils, capacitors, etc. and we should be pleased to give advice on other applications.

STERLING VARNISH CO. LTD. FRASER ROAD, OLD TRAFFORD, MANCHESTER 17.

Telephone: Trafford Park 0282 (4 lines)
Telegrams. 'Dielectric Manchester'

London Office and Warehouse: 6, London Road, Brentford, Middlesex. Tel: Isleworth 8133/4

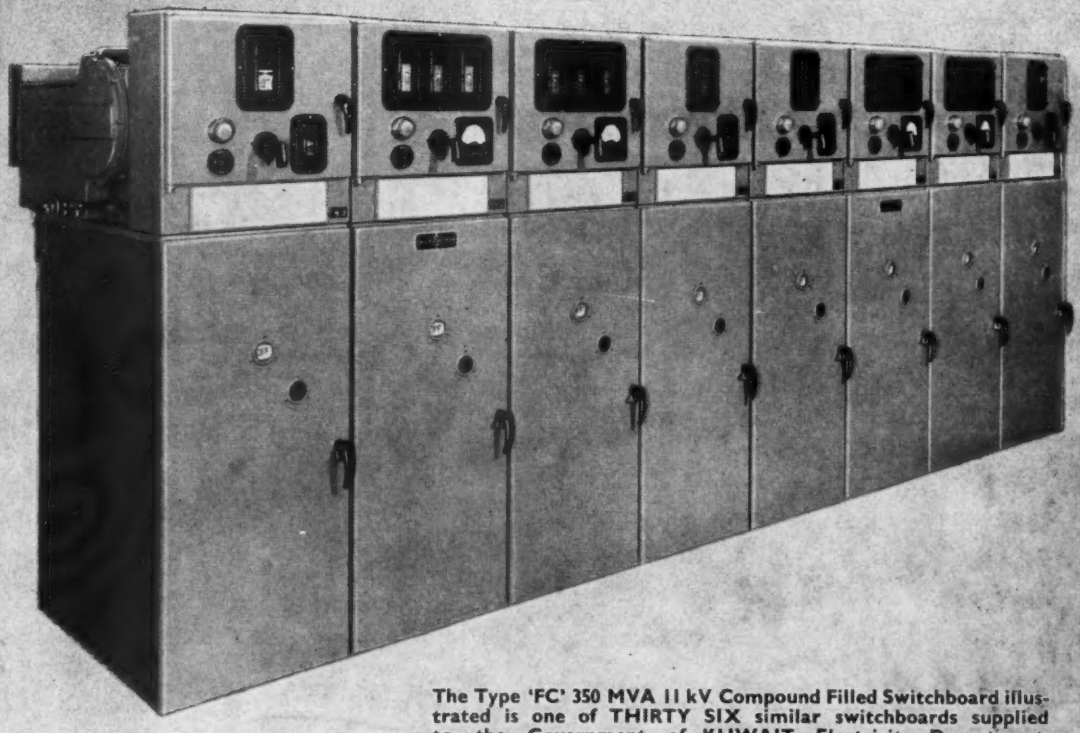
dm ST 23

MODERN,
ENDURING,
COMPETITIVE

H.V. SWITCHGEAR

OF QUALITY

- **ASTA Certificated to BS 116-1952 for Ratings up to 1600 amps 350 MVA at 11 kV**
- **Impulse Tested**
- **Complies with B.E.B.S. S2**
- **Air Insulated or Compound Filled**



The Type 'FC' 350 MVA 11 kV Compound Filled Switchboard illustrated is one of THIRTY SIX similar switchboards supplied to the Government of KUWAIT Electricity Department.

J. G. STATTER & CO. LTD.

82 VICTORIA ST., LONDON, S.W.1. Telephone: TATe Gallery 0436. Telegrams: SWITCHONIA, LONDON

WORKS — AMERSHAM COMMON, BUCKS

A Member of the Lancashire Dynamo Group

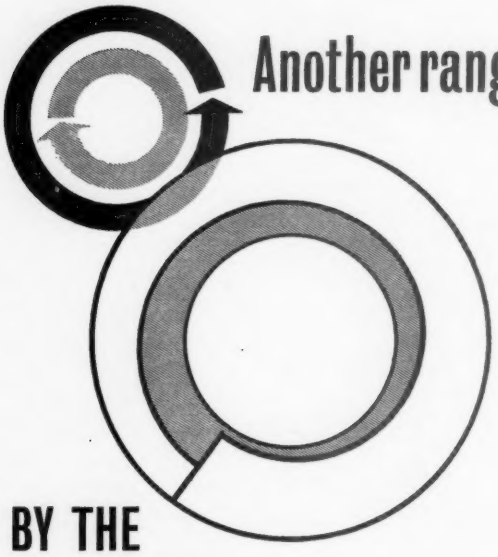
* Trademark of Imperial Chemical Industries Limited for their polytetrafluoroethylene resin.

"POLYPENCO" FLUOROCARBON TFE shapes are made from virgin polytetrafluoroethylene resins and are renowned throughout the world for quality, thus ensuring minimum waste, dependable "in-factory" production and reliable finished products. Ten years' experience in processing quality PTFE products ensures absolute reliability. You can utilise the unique properties of this outstanding material by contacting us today. Deliveries from stock or at short notice are our speciality.

We extrude and mould Polytetrafluoroethylene resins in a wide range of sizes in rods, tubes, tapes, thin wall electrical sleeving and bushing stock to close tolerances and in long lengths. Polypenco rod is available in lengths up to 8 feet ex-stock and to 12 feet by special order for machining on automatics. Chemical and electrical parts are also manufactured to customers' requirements. Send for leaflet listing the available shapes and sizes.

A.R.B. & A.I.D. approved.

POLYPENCO LIMITED 68–70 Tewin Road, Welwyn Garden City, Herts. *Telephone:* Welwyn Garden 5581–3.



Another range of bearing problems solved!

Self-exciting vibration of shafts within the oil film clearance and oil frothing are serious conditions which can halt the operation of high speed turbines and some other types of machinery.

Increased fundamental knowledge of bearings and lubrication, arising from our research programme, when applied to these problems has produced a simple new bearing design with a control valve. This enables oil film conditions in the bearing to be altered during running in such a manner as to suppress these faults. This new bearing also provides an increased degree of damping for vibration arising from external sources.

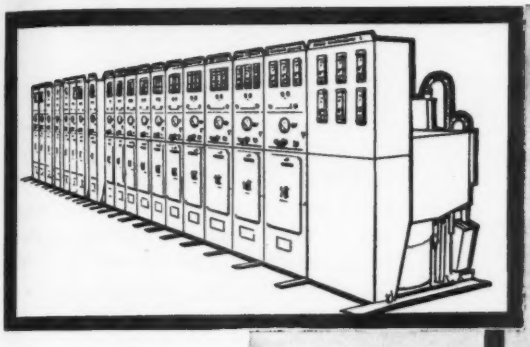
BY THE GLACIER *Anti-Whirl* BEARING

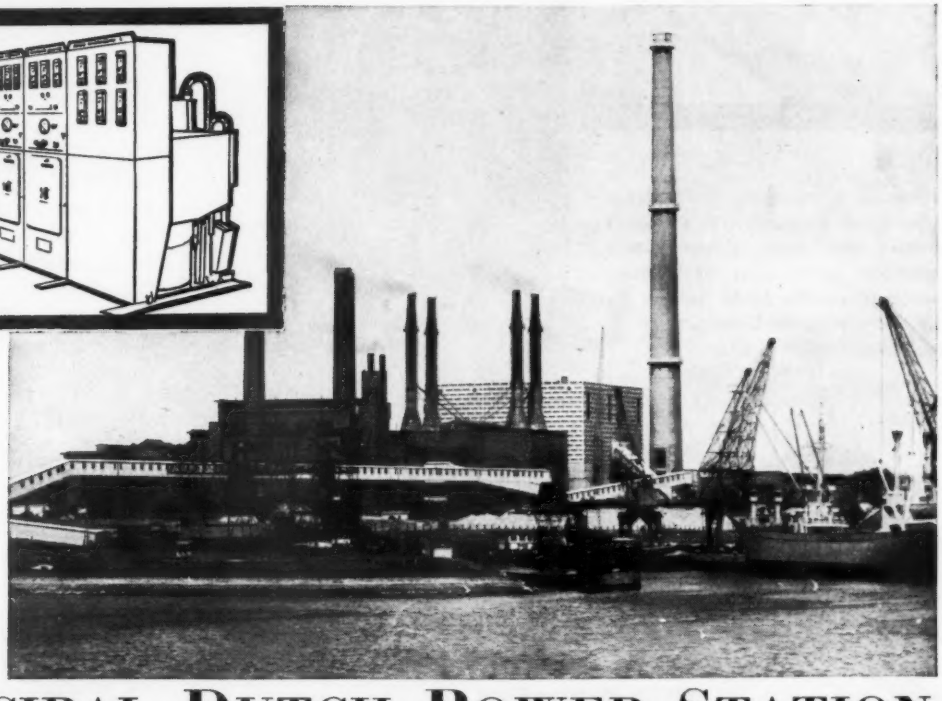
WRITE FOR TECHNICAL DATA, ETC.

GLACIER

THE GLACIER METAL CO LTD · ALPERTON · WEMBLEY · MIDDLESEX

YORKSHIRE SWITCHGEAR IN HOLLAND





A PRINCIPAL DUTCH POWER STATION

The installed capacity of this important Power Station is being doubled by the addition of two 125 MW turbo generating sets. *Yorkshire Switchgear* were selected to supply the two 20 panel 6kV 150MVA Metalclad Switchboards from their range of IVIF–13 equipment to control the auxiliaries of each set. The exacting requirements of B.S., I.E.C. and V.D.E. Specifications were embodied in the contract and strict compliance was proved by K.E.M.A. consultants.

This power Station, in addition to supplying electrical energy to a highly industrialized province of Holland, furnishes power to the Dutch Grid System, which links with the West German and Belgium systems, enabling Holland to exchange power not only with these two countries but also with France, Luxemburg, Switzerland, Italy and Austria.

In this, and in similar instances, *Yorkshire Switchgear* equipment is being selected because its advanced design and superior construction make it, in the opinion of many experts, the most modern and reliable in the world.

YOUR SYMBOL FOR RELIABILITY

YORKSHIRE SWITCHGEAR

AND ENGINEERING COMPANY LIMITED

MEANWOOD, LEEDS 6. Telephone: Leeds 57121-5

Yorkshire Switchgear are experienced in engineering whole projects from the electrical aspect and welcome initial enquiries.

WESTON

MOVING COIL RELAYS

Illustrated is the Model S170. Other types include the Model S124, a magnetic contact relay which operates with a minimum power input of 0.004 microwatt and the Model S115, a miniature relay, which functions as an "on-off" switching relay.

The simplicity and reliability of relay control for a wide variety of applications has led to the ever increasing use of Weston Moving Coil Relays.
Let us have a note of your relay problems and we will be pleased to advise on the most suitable model for any set of conditions. Enquiries should, if possible, be accompanied by full particulars of both control and local circuits.

SANGAMO WESTON

SANGAMO WESTON LIMITED · ENFIELD · MIDDLESEX

Tel: ENField 3434 (6 lines) & 1242 (6 lines) Grams: Sanwest, Enfield

Scottish Factory: Port Glasgow, Renfrewshire, Port Glasgow 41151 · Branches: London, CHAncery 4971 · Glasgow, Central 6208 Manchester, Central 7904 · Newcastle-upon-Tyne, Newcastle 26867 · Leeds, Leeds 30867 · Liverpool, Central 0230 · Wolverhampton, Wolverhampton 21912 · Nottingham, Nottingham 42403 · Bristol, Bristol 21781 · Southampton, Southampton 23328.

SW/67

Easier instruction by **UNILAB**

Thermionic Valve Units

GRD7

Based on the Ferranti GRD7, this UNILAB is the most versatile Diode unit available, all normal diode effects can be demonstrated, and in addition the axial field magnet supplied with each can be used to show the Magnetron effect. A 10,000 turn 50 mA Solenoid is also available. Dimensions 6" × 4" × 4½" high. Price £5 complete with Permanent Magnet. 10,000 turn Solenoid 22/6d.

EL 38

A new UNILAB Valve unit for those working with the Mullard literature on their EL. 38 type valve, fitted with shorting links for easy change to Triode, Tetrode or Pentode. 1,000 ohm resistor incorporated, complete with plugs and measuring 6" × 4" × 2½". Price 45/– + 7/10d. Purchase Tax.

Signal Diodes, Triodes and Pentodes are available all based on current types of receiving valves, complete with all necessary plugs for rapid connection. Dimensions 3" × 2" × 1¾".

Examples: Triode (½ ECC82) 17/6d. + 5/6d. Purchase Tax.
Pentode (EF85) 18/6d. + 5/6d. Purchase Tax.
Diode (½ EB91) 16/6d. + 3/7d. Purchase Tax.

Other UNILAB units include Cathode Ray Oscillograph, Power Supply Units, Transistors, Fixed and Variable Units of Capacitance, Resistance and Inductance. Amplifiers, etc., etc.

Send for UNILAB literature to:

RAINBOW RADIO (BLACKBURN) CO. LTD.,
Mincing Lane, Blackburn, Lancs. *Tel: Blackburn 4388.*

Prices shown do not apply in Canada or United States.

Canadian enquiries to exclusive distributors:
CONWAY ELECTRONIC ENTERPRISES,
1514, Eglinton Ave. West, TORONTO 10.

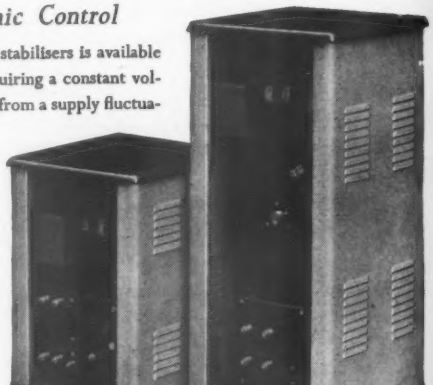
ZENITH
(REGD. TRADE MARK)

Automatic

VOLTAGE REGULATORS

with Electronic Control

A large range of stabilisers is available for installations requiring a constant voltage within ± 1% from a supply fluctuating up to ± 10% or − 15% to + 5%. Single and three phase models from 7 to 25 kVA per phase are detailed in our catalogue which will be sent on request.

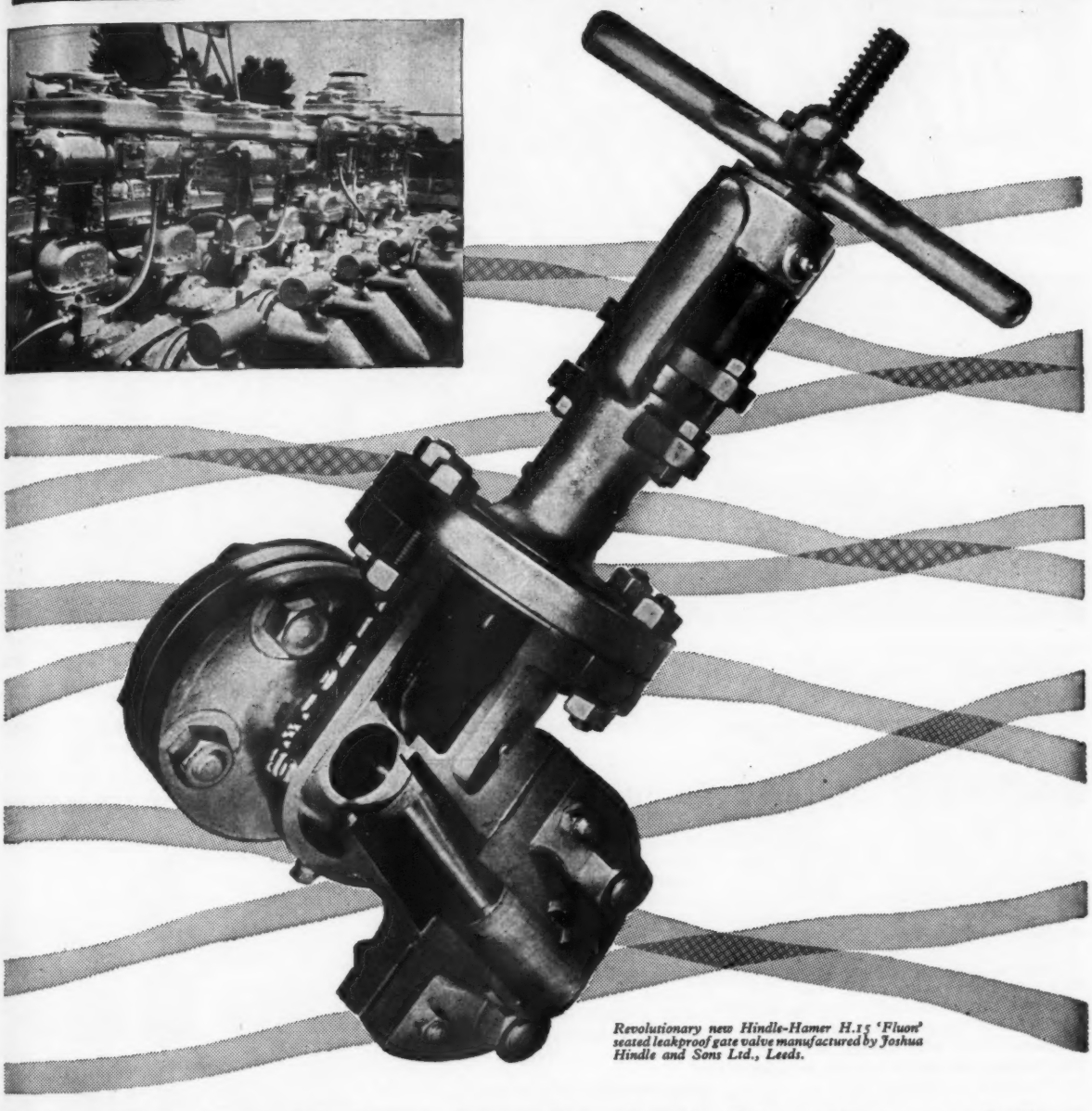


The ZENITH ELECTRIC CO. Ltd.
ZENITH WORKS, VILLIERS ROAD, WILLESDEN GREEN
LONDON, N.W.2

Telephone: WILlesden 6581–5 *Telegrams:* Voltaohm, Norphone, London

MANUFACTURERS OF ELECTRICAL EQUIPMENT
INCLUDING RADIO AND TELEVISION COMPONENTS

'FLUON' INCREASES PRODUCTION IN THE CHEMICAL INDUSTRY



Revolutionary new Hindle-Hamer H.15 'Fluon' seated leakproof gate valve manufactured by Joshua Hindle and Sons Ltd., Leeds.

Only 'Fluon' could have brought about this valve revolution

BECAUSE OF 'Fluon' Joshua Hindle and Sons Ltd. were able to perfect a revolutionary new leak proof valve. Their Hindle-Hamer H.15 gate valve incorporates a double sealing action. In addition to metal-to-metal fit of the wedge against the valve seats, two 'Fluon' p.t.f.e. seals are compressed against the wedge as it is lowered. This combination sealing action provides a positive shut-off both upstream and downstream, doing away with the need for a double block and bleeder in piping installations.

Had metal been used instead of 'Fluon', an eventual leak would have been unavoidable. 'Fluon', however, has a superior resistance to an extremely wide range of chemicals and, what is of tremendous importance, is not subject to pitting. That this 'Fluon' seated gate valve is perfectly leakproof has been proved both in practice and by exhaustive tests. After accelerated tests — equalling three years actual use — the valves were still in perfect condition and 100% leakproof. Undoubtedly, the Hindle-Hamer H.15 'Fluon' seated gate valve is ideal for any heavy duty application where a leakproof valve is essential.

'FLUON'

'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.

ICI IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1

PF.54

Weir

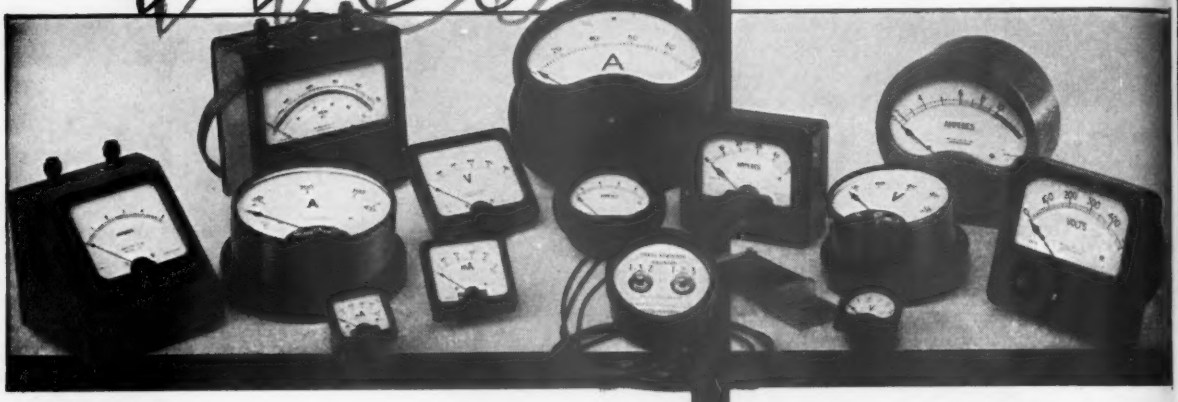
MANUFACTURERS OF ELECTRICAL INDICATING INSTRUMENTS AND ASSOCIATED EQUIPMENT

Miniature, Switchboard and Portable Instruments, Moving Coil, Moving Iron and Rectifier Types. Micro-ammeters, Milliammeters, Ammeters, Voltmeters, Frequency meters and Phase Sequence Indicators.

Special Shunts.

Transductors for the measurement of Heavy Direct Currents up to 20,000 amperes.

Gas and Oil operated relays for Transformer Protection (Buchholz Principle).



London Area Office
2 Hill Street, St. Albans, Herts. **Tel: St. Albans 51722**

Midland Office
94 Victoria Rd., Oxbarn, Wolverhampton. Tel: Wolverhampton 38723

THE WEIR ELECTRICAL INSTRUMENT CO. LTD.
Head Office and Works: Bradford-on-Avon Wiltshire. Tel. Bradford-on-Avon 2044/5.

ELMET Sintered Compound Metals in Electrical Engineering

POWDER METALLURGY permits the production of metals and compounds with properties previously unattainable. The ELMET range of sintered compound metals combine conductivity, hardness and arc-resistance to a degree impossible with alloys of Copper or Silver. Most of these compounds are based on metallic Tungsten and retain in a notable degree its high melting point, hardness and resistance to erosion by arcing, while offering much higher conductivity and minimum proneness to oxidation.

These compound metals are not alloys: their constituents thus retain their own respective properties. Such a compound is a matrix of Tungsten with its interstices completely filled with Copper or Silver: the resultant properties can be modified by varying the proportions used.

The ELMET range is made up as follows—

COPELMET (Copper-Tungsten) in four standard combinations.

SILVELMET (Silver-Tungsten) in two standard combinations.

SILNO (Silver-Nickel)—one standard grade.

SILNO 90 (Silver Cadmium Oxide)—one standard grade.

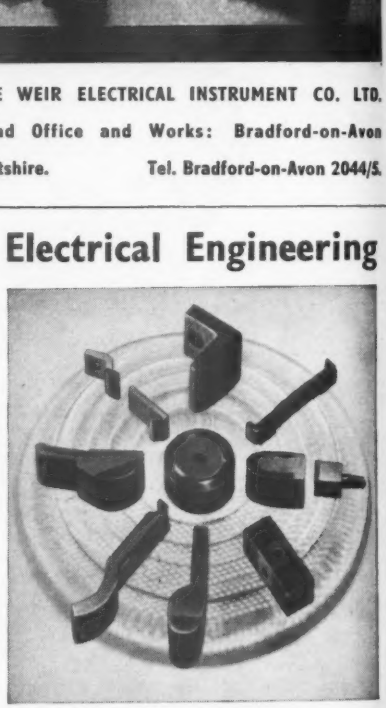
Special combinations and grades are produced for specific applications. Examples are Silver-Molybdenum, Copper-Tungsten-Carbide, etc. Correctly chosen, ELMET metals give longer contact life, freedom from sticking and welding, improved overload behaviour, reduced maintenance and downtime.

Typical applications are—
Contacts for high voltage switchgear, circuit breakers, interruptors, on-load tap changers, contactors, controllers, starters and relays.

Other interesting applications are—
Facings for projection welding and butt welding electrodes or dies, radiation screening material, balance weights, and consumable electrodes for spark machining complicated shapes.

ELMET metals are normally applied in the form of tips brazed to copper or copper alloy bodies or with vacuum-cast copper backings. Brazing is quite straightforward using normal techniques and silver solder. Complete tipped contacts can be supplied ready for use, or, alternatively, tips can be supplied loose, or in some cases worn contacts can be recovered by re-tipping.

Full information is available on request: please ask for Publication No. 13

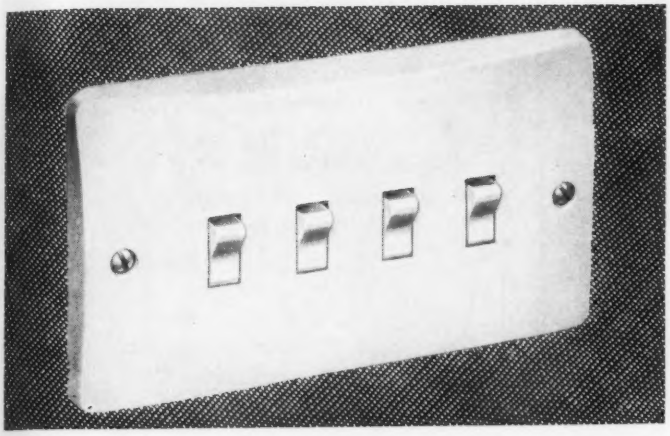


A selection of ELMET tipped contacts.

METRO-CUTANIT

METRO-CUTANIT LIMITED
Associated with Metropolitan-Vickers Electrical Co. Ltd.
GRAPPENHALL WARRINGTON LANCASHIRE

NEWS from MK



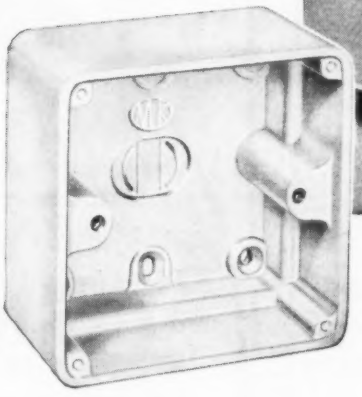
A NEW 4-GANG PLATESWITCH

This new plaster-depth Plateswitch has 4¾″ fixing centres and is therefore suitable for mounting in the existing 3-gang boxes. All the switches are two-way and may be wired either one-way or two-way. Moulded in brown or ivory, overall size 5¾″ x 3⅜″.

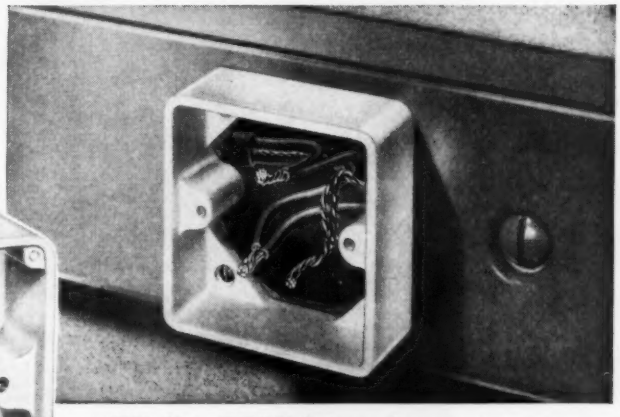
12/6 each Brown
13/- each Ivory

CONVERSION BOXES

This simple and convenient method of mounting flush accessories with 2¾″ fixing centres as surface units has been further extended by the introduction of two new designs. The moulded boxes have 4 BA tapped brass inserts. The two patterns shown have been developed for special purposes and have ample wiring room.



LIST No. 2031
This is a deep moulded box intended for use with DP switched fused spur-boxes.
1/6 each Brown
1/8 each Ivory



LIST No. 2035 (above) Designed for mounting on panels or trunking this moulded box requires only a simple circular cut-out for access at the back. It will accept any MK flush accessory with 2¾″ fixing centres.
1/- each Brown **1/2** each Ivory

WE HAVE MOVED TO NEW OFFICES

The new MK administrative block at Shrubbery Road is now complete, and this is our new registered office. Please note the change of address.

MK 173 DHB

MK ELECTRIC LIMITED · SHRUBBERY ROAD · LONDON N.9 · EDMONTON 5151

Straight through

to fuel economy

If waste heat in the flue gases is to be put to economical use, a delicate balance must be struck between effective exchange and impedance to the draught.

Senior Economisers are designed to do just this. The H-gills allow straight unobstructed passage to the flue gases while exposing the maximum amount of heat transfer surface.

The uniform cross-section of these vertical passages also means less tendency for dust and soot deposits and consequently draught loss does not noticeably increase even with long service. Send now for further details.

Senior H TUBE economisers *for cheaper steam*

Senior Economisers Limited
Northumberland House
303–306 High Holborn, London W.C.1
Tel: Chancery 8173 (8 lines)

TA 2441

TIME FOR POWER!

In many Electrical generating stations throughout the world you will find that it is a Gents' timing device which is relied upon to control the periodicity of the supply.
We are especially concerned in making products which control things, in industry and commerce.

Be it timing devices or warning devices, all are made to the same high standard of accuracy and dependability.

GENTS' *OF LEICESTER*

ELECTRICAL PRODUCTS

GENT & CO. LTD · FARADAY WORKS · LEICESTER

London Office and Showroom: 47, Victoria St., S.W.1.

Also at: BELFAST · BIRMINGHAM · BRISTOL · EDINBURGH
GLASGOW · NEWCASTLE

Electrical Products include:– Controlled Electric Clock Systems, Synchronous Clocks, Time Recorders, Fire Alarms, Industrial and Domestic Bells and Buzzers, Indicators, Burglar Alarms, Staff Location Systems, Luminous Call Systems, Relays etc.

Over 200 MVA in one shipment for Rhodesia

Fully tested, including full load heat run and impulse tests at 1035 kV and 1550 kV respectively.

The transformers shown above comprise the third of six 60 MVA, 220 kV transmission transformers and two of ten 80 MVA, 330 kV generator transformers.

'ENGLISH ELECTRIC'
transformers

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

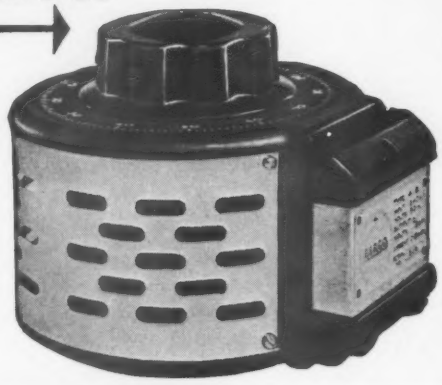
Transformer Department, Stafford

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

TFS.25

A UNIVERSAL A.C. VOLTAGE & CURRENT CONTROL
. . . with universal fixing centres

For the most up-to-date variable transformers . . . for early delivery, too, the obvious choice is the Berco Rotary Regavolt, model 42A, rated at 580 V.A. With a maximum input voltage of 250 V. it will supply a variable output from 0-270 V. Moderately priced at £7.0.9*d.* (skeleton type) and £8.5.11*d.* (protected type as illustrated) the Berco Rotary Regavolt represents the finest value today at the lowest cost.



* **CONSTRUCTION:** Toroidally wound auto-transformers, with tracks formed on one face of the windings.
* **CORE:** Wound from a continuous strip of low loss electrical steel in a similar manner to the well-known C core construction.
* **INSULATION:** Specially processed plastic mouldings ensure minimum shrinkage due to heat and continuous use, and prevent any possibility of the turns slackening.
* **WINDING:** Of high conductivity copper, insulated with a synthetic enamel of the polyvinyl acetal-phenal formaldehyde resin type, giving good space factor, exceptionally high abrasion resistance and prolonged heating resistance.
* **FRAME:** Of die cast aluminium, incorporating long spindle bearings and mounting feet to ensure accuracy and rigidity of the mechanism in relation to the fixing holes.
* **BRUSHES:** The brushes are of a special carbon for its contact resistance characteristics, shaped to give minimum loss, maximum strength and longest life.

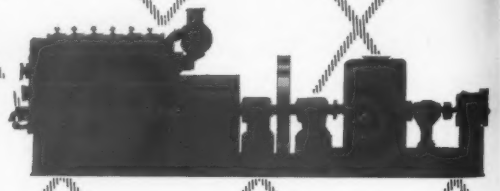
BR1341-BXH

BERCO

* *Write for list 615A giving full technical details of this and other models in the Rotary Regavolt range.*

THE BRITISH ELECTRIC RESISTANCE CO. LTD.,
QUEENSWAY, MIDDLESEX
Telephone: HOWard 2411 Telegrams: Vitrohm, Enfield
Specialists in the control of current and voltage for more than 25 years

'NO-BREAK' GENERATING PLANT up to 425kW



When *continuous* supply is essential

LISTER BLACKSTONE

Three "No Break" systems are available:

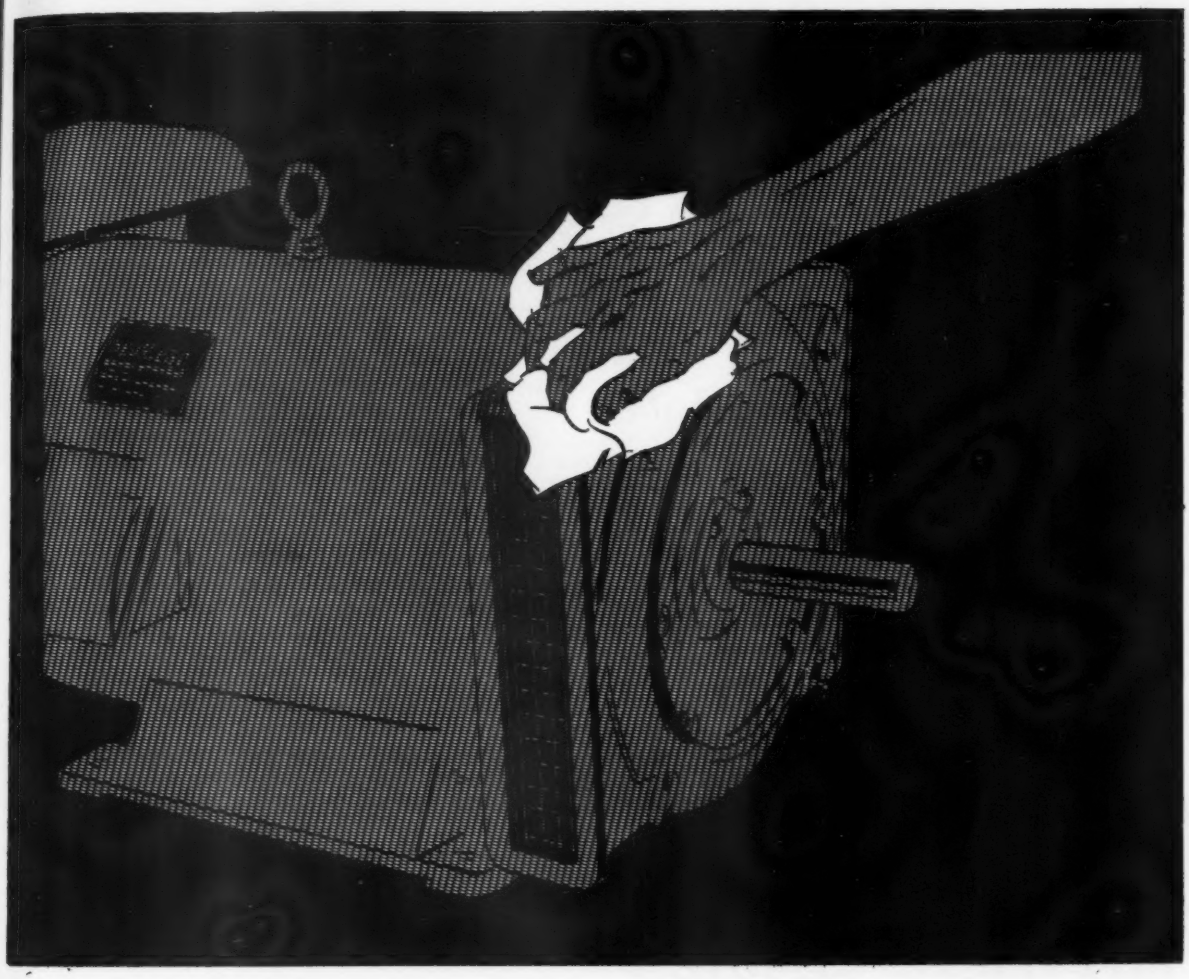
1. Synchronous motor/alternator.
2. Induction motor and alternator where voltage transience cannot be tolerated.
3. D.C. Generator, D.C. Motor and alternator where voltage transience and frequency drift cannot be tolerated.

PROVIDES THE POWER!

All Blackstone engines are available fitted with the patented Blackstone Nodal Damper Coupling. This coupling provides a degree of flexibility and forced viscous damping which gives a perfectly smooth drive to any driven machinery whatever the speed of the engine.

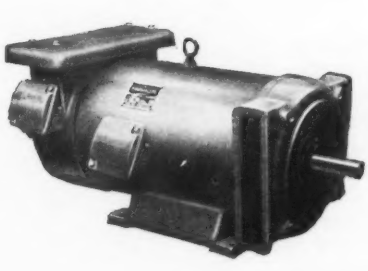
BLACKSTONE & COMPANY LIMITED

A member of the Lister Group of Companies, Dursley, Gloucestershire. Phone: 2371. London office: Imperial House, Kingsway, W.C.2. Phone: TEMple Bar 9681.



Electrical maintenance

—with a duster



Because it has no brushes, no slip rings, no commutators, no frictional surfaces, the Macfarlane Brushless Alternator requires only to be kept clean to run smoothly and reliably throughout its life. Carbon or copper dust does not occur. There is no external control gear to adjust and only one moving part, with grease packed bearings. Available in a range of outputs from 10—150 KVA. Voltage regulation $\pm$ 1½% as standard. Completely stable, hot or cold.

THE MACFARLANE ENGINEERING COMPANY LIMITED

Netherlee Road, Cathcart, Glasgow, S4.
Telephone: MERrylee 2255/7.

"Where do YOU bank?"

"At GLYN MILLS in Whitehall"

HE knows the value of a centrally-placed bank which, trained to deal with the financial problems of serving officers, at home and abroad, has developed a modern, efficient banking service designed not only for them but for civilians as well. If you have a banking problem, why not let us discuss it with you?

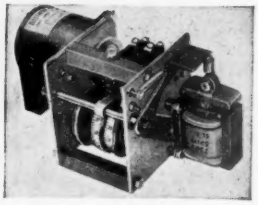
GLYN, MILLS & CO., HOLT'S BRANCH
KIRKLAND HOUSE, WHITEHALL, LONDON, S.W.1
BANKERS:
Head Office: 67 LOMBARD STREET, E.C.3
Associate Banks:
The Royal Bank of Scotland Williams Deacon's Bank Limited

150th Anniversary 1809-1959

ELECTRICAL REMOTE CONTROL CO. LTD.

Manufacturers of Electrical Timing and Control Apparatus

- **Range of fully automatic process timers for AC and DC.**
- **Range of cam operated hand reset process timers for AC and DC.**
- **Multiple contact and mercury relays for AC and DC.**
- **Special purpose control panels to customers' requirements.**



Miniature automatic synchronous timer type AMS. 1–3 continuously adjustable independent timing circuits. Timing ranges between 0–30 seconds and 0–28 days. Automatic reset within ½ second. Switching capacity 10 amps at 230 v AC. Overall dimensions of 2-circuit unit 2¾″ × 3½″ × 6½″.

HARLOW, ESSEX
Tel.: Harlow 24285

'Don't blow your top!'

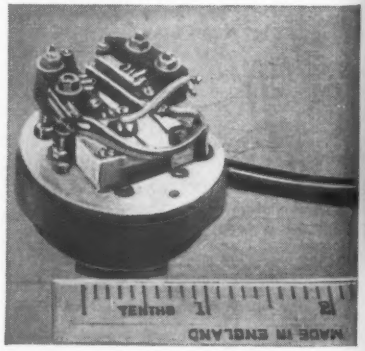
fit an M.B. METALS

PRESSURE SWITCH for reliability

This latest addition to the M.B. Metals range of precision control equipment has been designed to meet the stringent requirements of the aircraft and general engineering industries for pneumatic or hydraulic systems.

High accuracy pressure indication at two preset levels with a working range of 50 to 6000 p.s.i.

Specification sheet MPS 200 available on request.



M.B. METALS LTD.
VALE WORKS · PORTSLADE . SUSSEX
TELEPHONE . HOVE 48623

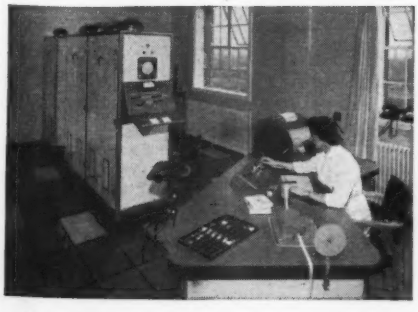
the Stantec ZEBRA

ELECTRONIC DIGITAL COMPUTER

The Stantec Zebra computer has a low capital cost and at the same time has the advantage of a large store of over 8,000 words each of nine decimal digits. It has an operation speed of 312 microseconds per instruction and there is available an interpretive decimal floating point programming code which has been characterized as one of the simplest of all the British computers.

We should be glad to discuss your problem and if requirements do not warrant the purchase of a computer we suggest you consider the facilities of our Computer service bureaux.

Two Zebra Computers can be purchased for a price and output comparable with one large machine with the added advantages of greater flexibility, easier allocation of work and safeguard against breakdown.



SOME OF THE JOBS ZEBRA IS DOING:—

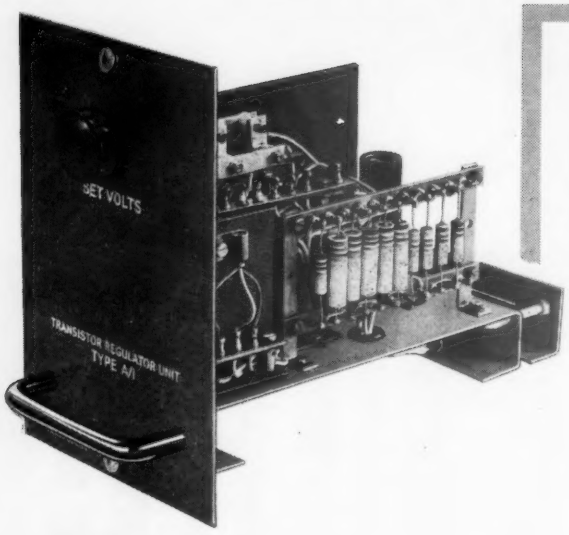
AERODYNAMIC CALCULATION
WIND TUNNEL DATA REDUCTION
PRODUCTION CONTROL
SALES FORECASTING
OPTICAL DESIGN
TELEPHONE NETWORK DESIGN
HYDRO DYNAMIC DESIGN
INVOICING AND STOCK CONTROL

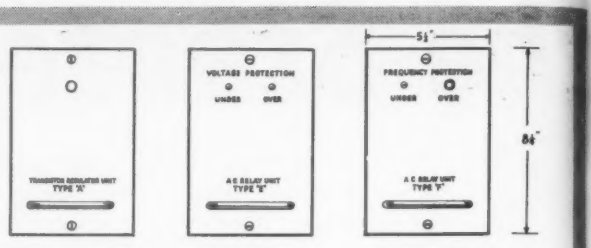
STC ELECTRONIC SYSTEMS GROUP

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

INFORMATION PROCESSING DIVISION: CORPORATION ROAD · NEWPORT · MON.





TRANSISTOR A.V.R. | OVER AND UNDER VOLTAGE RELAY | OVER AND UNDER FREQUENCY RELAY

Vernons

INDUSTRIES Ltd
LIVERPOOL

The ultimate in reliability

TRANSISTORISED CONTROL UNITS

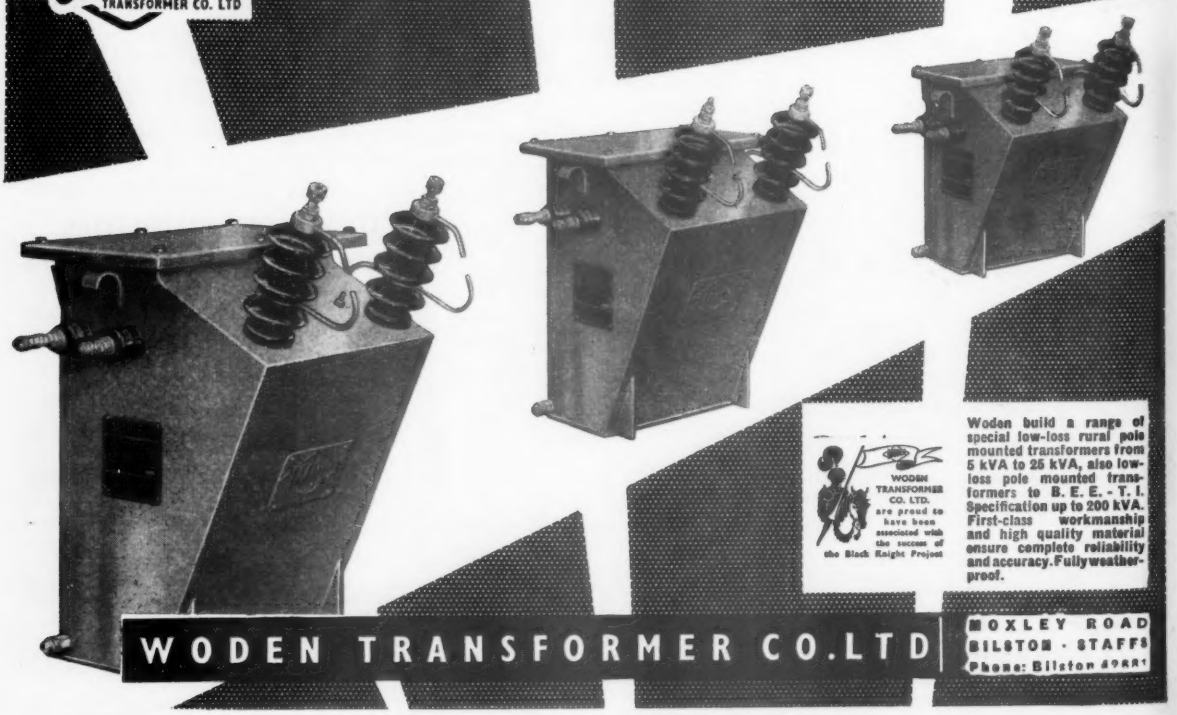
- AUTOMATIC VOLTAGE REGULATORS
- OVER AND UNDER VOLTAGE PROTECTION RELAYS
- OVER AND UNDER FREQUENCY PROTECTION RELAYS

Each unit is built on a standard compact frame for interchangeability. Complete reliability proved by many thousands of hours of trouble-free service in Vernons G.P.U.s. A.V.R.s completely static, no wear or inertia problems. Lightning fast response to voltage variations. Unaffected by vibration. Now available to you.

KIRKBY INDUSTRIAL ESTATE, LIVERPOOL... Tel. SIMonswood 3261

WODEN TRANSFORMER CO. LTD

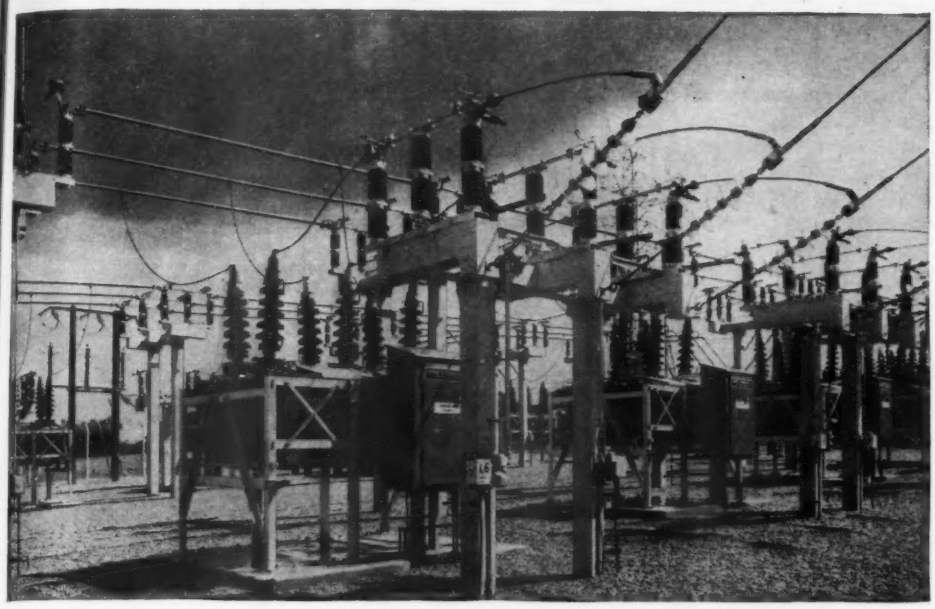
POLE MOUNTED TRANSFORMERS



Woden build a range of special low-loss rural pole mounted transformers from 5 kVA to 25 kVA, also low-loss pole mounted transformers to B. E. E. - T. I. Specification up to 200 kVA. First-class workmanship and high quality material ensure complete reliability and accuracy. Fully weatherproof.

WODEN TRANSFORMER CO. LTD

MOXLEY ROAD
BILSTON · STAFFS
Phone: Bilston 49881



For outdoor or indoor switchgear up to and including 66kV

OWNERS OF AN APPROVED ASTA TESTING STATION

COOKE & FERGUSON LTD.,

IN ASSOCIATION WITH

CROMPTON PARKINSON LIMITED

CROMPTON HOUSE · ALDWYCH · LONDON W.C.2

CERAMIC VALVEHOLDERS - NOW ECONOMIC IN EVERY STAGE!

INSULATION RESISTANCE: greater than 20×10^{12} ohms (measured at 500V d.c.)

BREAKDOWN VOLTAGE BETWEEN CONTACTS: greater than 3.5 kV d.c.

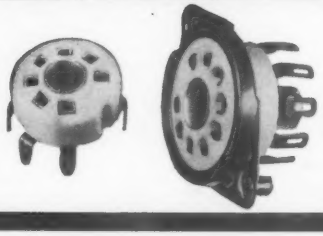
POWER FACTOR OF CERAMIC: better than 0.001

CONTACT RESISTANCE: less than 4 milli Ω

CAPACITANCE VALUE: less than 0.5pF pin to pin at 1 Mc/s.

For low moisture absorption, high insulating qualities and resistance to temperature, high stability ceramic valveholders are the obvious choice, and Plessey offer you a wide range at attractive prices. This is because they have successfully overcome certain manufacturing difficulties with ceramic materials and can now pass on to you the advantages of economic production. The exclusive design of the contact ensures constant pressure and low contact resistance throughout the working life.

Write now for samples and prices.

ceramic  valveholders

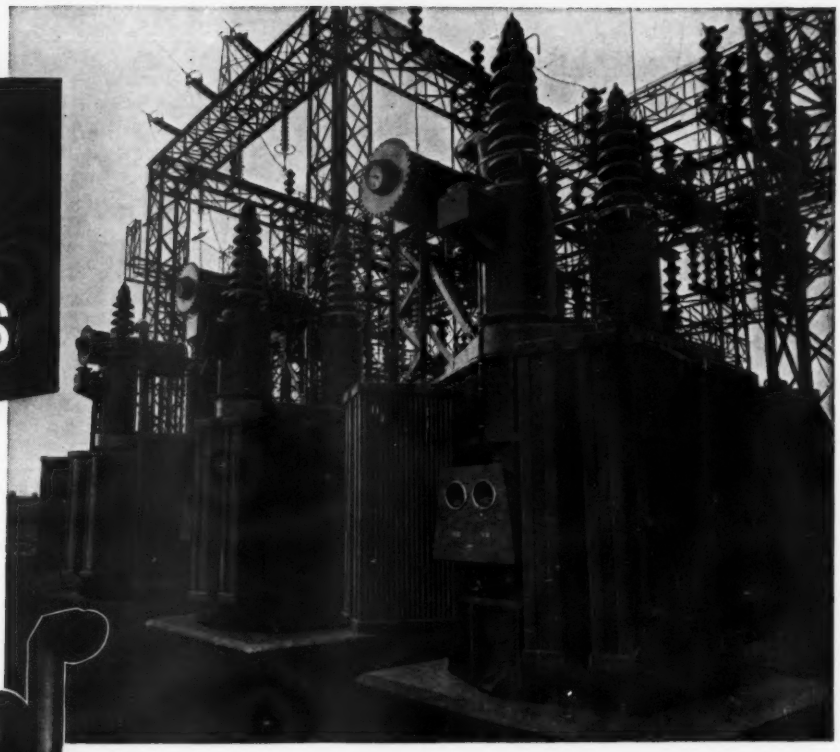
Plessey

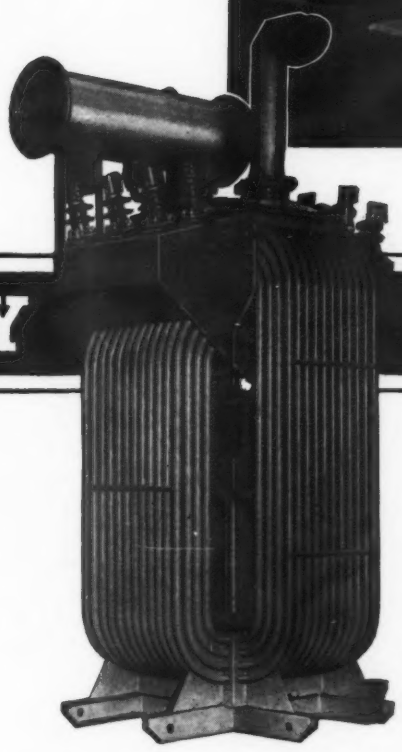
CHEMICAL AND METALLURGICAL DIVISION · COMPONENTS GROUP
THE PLESSEY COMPANY LIMITED · WOOD BURCOTE WAY · TOWCESTER
NORTHANTS · TELEPHONE: TOWCESTER 312

Overseas Sales Organisation:
PLESSEY INTERNATIONAL LIMITED · ILFORD · ESSEX · ENGLAND · TELEPHONE: ILFORD 3040

TC10

CURRENT LIMITING REACTORS





BY HACKBRIDGE

Whether magnetically or copper shielded, Hackbridge reactors embody the Hackbridge principle of unit construction: in either type the whole assembly constitutes a rigid structure of exceptional mechanical strength to withstand the largest electromechanical stresses met with under service conditions. Send for publication DB.18/1.

The illustrations show typical Hackbridge magnetically shielded reactors. Above: at Coventry Generating Station for introducing 18% reactance into the 90 MVA 132 kV. system; and below, for introducing a 3.75% reactance into a 30 MVA 6.6 kV. system.

HACKBRIDGE AND HEWITTIC ELECTRIC CO., LIMITED
WALTON-ON-THAMES - SURREY - ENGLAND

Telephone: Walton-on-Thames 28833 (8 lines) Telegrams & Cables: "Electric, Walton-on-Thames"

OVERSEAS REPRESENTATIVES: ARGENTINA: H. A. Roberts & Cia., S.R.L., Buenos Aires. **AUSTRALIA:** Hackbridge and Hewittic Electric Co., Ltd., 171, Fitzroy Street, St. Kilda, Victoria; N.S.W.: Queensland: W. Australia: Elder, Smith & Co. Ltd.; South Australia: Parsons & Robertson Ltd.; Tasmania: H. M. Bamford & Sons (Pty.) Ltd., Hobart. **BELGIUM & LUXEMBOURG:** Pierre Pollie, Brussels 3. **BRAZIL:** Oscar G. Mors, Sao Paulo. **BURMA:** Neonlite Manufacturing & Trading Co. Ltd. Rangoon. **CANADA:** Hackbridge and Hewittic Electric Co. of Canada Ltd., Montreal; The Northern Electric Co. Ltd., Montreal, etc. **CEYLON:** Envee Ess Ltd., Colombo. **CHILE:** Sociedad Importadora del Pacifico Ltda., Santiago. **EAST AFRICA:** G. A. Neumann Ltd., Nairobi. **EGYPT:** Giacomo Cohenca Fils, S.A.E., Cairo. **FINLAND:** Sähkö-ja Koneliike O.Y. Hermes, Helsinki. **GHANA, NIGERIA & SIERRA LEONE:** Glyndova Ltd. **GREECE:** Charilaos C. Coroneos, Athens. **INDIA:** Steam & Mining Equipment (India) Private Ltd., Calcutta; Easun Engineering Co. Ltd., Madras 1. **IRAQ:** J. P. Bahoshy Bros., Baghdad. **MALAYA, SINGAPORE & BORNEO:** Harper, Gilfillan & Co. Ltd., Kuala Lumpur. **NETHERLANDS:** J. Kater E.I., Ouderkerk a.d. Amstel. **NEW ZEALAND:** Richardson McCabe & Co. Ltd., Wellington, Etc. **PAKISTAN:** The Karachi Radio Co., Karachi 3. **SOUTH AFRICA:** Arthur Trevor Williams (Pty.) Ltd., Johannesburg, etc. **CENTRAL AFRICAN FEDERATION:** Arthur Trevor Williams (Pty.) Ltd., Salisbury. **THAILAND:** Vichien Phanich Co. Ltd., Bangkok. **TRINIDAD & TOBAGO:** Thomas Peake & Co., Port of Spain. **TURKEY:** Dr. H. Salim Oker, Ankara. **U.S.A.:** Hackbridge and Hewittic Electric Co. Ltd., P.O. Box 234, Pittsburgh 30, Pennsylvania. **VENEZUELA:** Oficina de Ingenieria Sociedad Anomina, Caracas.

PUBLISHED BY THE INSTITUTION OF ELECTRICAL ENGINEERS. PRINTED BY UNWIN BROTHERS LIMITED, WOKING AND LONDON

PRINCIPAL FEATURES OF THIS ISSUE

THE READING OF TECHNOLOGISTS

MATERIALS HANDLING AND AUTOMATION

SOME RECENT DEVELOPMENTS IN ELECTRICAL INSULATION

STATISTICS AND ENGINEERING

PUBLIC MOBILE RADIOTELEPHONE SERVICE

The full list of contents of the issue will be found on the inside front cover

INDEX OF ADVERTISERS

Alfa-Laval Co. Ltd. *xi*
Allen West and Co. Ltd.
Aluminium Union Ltd.
Aluminium Wire and Cable Co. Ltd.
Edward Arnold Publishers Ltd.
Associated Electrical Industries Ltd. *xviii*
Automat
Automatic Telephone and Electric Co. Ltd. *xxix*

Balfour, Beatty and Co. Ltd.
Belmos Co. Ltd. *xiii*
Birfield Industries Ltd.
Blackstone and Co. Ltd. *xlviii*
British Driver-Harris Co. Ltd. *xv*
British Electric Resistance Co. Ltd. *xlviii*
British Insulated Callender's Cables Ltd.
Brookhirst Igranic Ltd. *v*

Cable Makers Association *xxxiv*
Cable Supports Ltd.
Cambridge University Press
B. and F. Carter and Co. Ltd. *xxxviii*
Cooke and Ferguson Ltd. *liii*
J. A. Crabtree and Co. Ltd. *vi & vii*
Crofts (Engineers) Ltd. *xxiv*
Crompton Parkinson Ltd. *liii*

Donovan Electrical Co. Ltd.

Electric Construction Co. Ltd.
Electrical Apparatus Co. Ltd.
Electrical Remote Control Co. Ltd. *l*
Electroflo Meters Co. Ltd. *xxxv*
Elga Products Ltd.
English Electric Co. Ltd. *xlvii*
English Universities Press Ltd.
Everett Edgcumbe and Co. Ltd.
Evershed and Vignoles Ltd.
Expanded Metal Co. Ltd. *xiv*

Falk, Stadelmann and Co. Ltd.
Formica Ltd.
Fuller Electric Ltd.

Gardners Radio Ltd.
General Electric Co. Ltd. (Atomic Energy Division)
General Electric Co. Ltd. (Heavy Eng. Div. Power Plant) *xvi & xvii*
General Electric Co. Ltd. (M-O Valves)
General Electric Co. Ltd. (Semiconductors)
Gent and Co. Ltd. *xlvi*
Glacier Metal Co. Ltd. *xl*
Glyn, Mills and Co. *l*

Hackbridge and Hewittic Electric Co. Ltd. *IBC*
Hallam, Sleigh and Cheston Ltd.
Harland Engineering Co. Ltd. *xxx*
Heenan and Froude Ltd.
W. T. Henley's Telegraph Works Co. Ltd.
Heyes and Co. Ltd.

Imperial Chemical Industries Ltd. *xxvi & xliii*
Insuloid Mnfg. Co. Ltd.
Isopad Ltd.

Johnson, Matthey and Co. Ltd.

Key Engineering Co. Ltd.

Lodge-Cottrell Ltd.
Londex Ltd. *xxxviii*

Macfarlane Engineering Co. Ltd. *xlix*
Marrison and Catherall Ltd.
Mersey Cable Works Ltd.
Metaducts Ltd.
Metallic Seamless Tube Co. Ltd.
M.B. Metals Ltd. *l*
Metro-Cutanit Ltd. *xliv*
Micanite and Insulators Co. Ltd.
Midland Dynamo Co. Ltd.
Midland Electric Mnfg. Co. Ltd.
Midland Silicones Ltd. *xxviii*
Mitchell Engineering Ltd.
M.K. Electric Ltd. *xlv*
Modern Acoustics Ltd.
Morgan Crucible Co. Ltd. *xxxi*
Mullard Ltd. (Semiconductors) *xxii & xxiii*
Mullard Ltd. (Valves) *xxv*
Mycalex and T.I.M. Ltd.

National Salt Glazed Pipe Mnfrs.' Association *i*
James Neill and Co. (Sheffield) Ltd.
North British Rubber Co. Ltd.
Northern Aluminium Co. Ltd. *ii & iii*

Ottermill Switchgear Ltd.
Oxford University Press

Pelapone Engines Ltd. *xxvii*
Permanent Magnet Association *xix*
Pirelli-General Cable Works Ltd.
Sir Isaac Pitman and Sons Ltd.
Plannair Ltd.
Plessey Co. Ltd. *liv*
Polypenco Ltd. *xl*
Professional Engineers Appointments Board
Pye Telecommunications Ltd.

Rainbow Radio (Blackburn) Ltd. *xlii*
Ransome and Marles Bearing Co. Ltd.
Record Electrical Co. Ltd. *xxxii*
A. Reyrolle and Co. Ltd. *viii*

Sangamo Weston Ltd. *xlii*
George H. Scholes and Co. Ltd.
Semiconductors Ltd. *xxxvi*
Senior Economisers Ltd. *xlvi*
Arthur Shaw and Co. Ltd. *xxxiii*
Shell-Mex and B.P. Ltd. *xx & xxi*
Siemens Edison Swan Ltd.
Simon-Carves Ltd.
Smiths Aircraft Instruments Ltd.
Square D Ltd. *xii*
Standard Telephones and Cables Ltd. *ix, x & li*
J. G. Statter and Co. Ltd. *xxxix*
Steatite and Porcelain Products Ltd.
Sterling Cable Co. Ltd.
Sterling Varnish Co. Ltd. *xxxviii*
Stream-Line Filters Ltd. *iv*

Telegraph Construction and Maintenance Co. Ltd.
Texas Instruments Ltd.
Richard Thomas and Baldwins Ltd.

Uni-Tubes Ltd.

Vernons Industries Ltd. *liii*

Weir Electrical Instrument Co. Ltd. *xliv*
Westool Ltd.
White and Riches Ltd. *xxxvii*
Whiteley Electrical Radio Co. Ltd.
Woden Transformer Co. Ltd. *liii*

Yorkshire Imperial Metals Ltd.
Yorkshire Switchgear and Engineering Co. Ltd. *xli*

Zenith Electric Co. Ltd. *xlii*

9041